**National Park Service**
**U.S. Department of the Interior**

**Natural Resource Program Center**

# San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol

*Version 6.4*

Natural Resource Report NPS/SFAN/NRR—2010/245

**ON THE COVER**
Female northern spotted owl and fledglings in Point Reyes National Seashore, 2007.
Photo by Heather Jensen, NPS.

# San Francisco Bay Area Network
# Northern Spotted Owl Monitoring Protocol

*Version 6.4*

Natural Resource Report NPS/SFAN/NRR—2010/245

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## Revision History Log

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| 6.3 | April 2010 | D. Press, D. Adams, H. Jensen, K. Fehring, B. Merkle, M. Koenen, L. Starcevich | Report format edits. Expanded NSO background info. Revised monitoring objectives. Added management triggers. New power analyses and sampling design recommendations from University of Idaho. Added documentation of SOD. Provided details on methods for long-term analyses. | To address peer review comments and meet current formatting guidelines. | 6.4 |

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## Executive Summary

This protocol and the attached standard operating procedures detail the background, field methods, data management, annual and long-term reporting and analyses, and operational requirements to monitor northern spotted owls (NSO) at Golden Gate National Recreation Area, Muir Woods National Monument, and Point Reyes National Seashore in California. The owls are listed as threatened under the Endangered Species Act and face a variety of threats in Marin County including loss of habitat due to development and catastrophic fire, displacement by barred owls (*Strix varia*), change in habitat due to Sudden Oak Death, human disturbances during the breeding season, and mortality due to West Nile Virus.

The parks included for monitoring by this protocol and surrounding Marin County compose the southernmost range of the NSO. Although NSO are typically found in old growth forests, in Marin NSOs reside in second growth Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens)*, bishop pine (*Pinus muricata)*, mixed conifer-hardwood, mixed evergreen hardwood forests, as well as remnant old-growth stands of coast redwood and Douglas-fir. The primary food source for the NSO is the dusky-footed woodrat (*Neotoma fuscipes*).

NSO density and fecundity monitoring began in 1993 after an infusion of funding associated with the Vision Fire at Point Reyes National Seashore. In 1999, the NPS and partners began regular long-term monitoring at 46 select NSO territories. Field methods follow those of the USDA Forest Service Pacific Northwest Research Station Protocol (PNW) with slight modification to reduce mousing and associated habituation to people. The monitoring program continues to the present using a new randomized sampling design that was initiated in 2007.

The long-term monitoring objectives are to:

1. Monitor long-term trends in NSO site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.

2. Monitor long-term trends in NSO fecundity (number of female young per territorial female) within NSO territories within the legislated NPS boundaries of Marin County, California.

3. Determine long-term trends in NSO nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

The sample design presented in this protocol includes an annual panel of 28 randomly selected sites with all remaining sites divided equally into four rotating panels of 8 sites each. That means a total of 36 sites will be monitored annually to determine occupancy. Fecundity determination will occur at every site occupied by a territorial female, no matter if the site is within the annual panel or one of the rotating panels. The selected sample design has a power of 99% to detect a 4% annual decline in occupancy in 5 years ($\alpha = 0.20$) and 80% power to detect a 10% annual decline in fecundity in 5 years ($\alpha = 0.20$). Nest tree characteristics will be recorded for every nest detected during monitoring. In addition, a SOD Severity Index has been developed and will be calculated to track SOD around activity centers.

Surveys are conducted during the breeding season from March until the end of July. To determine occupancy, surveyors will make a minimum of 3 site visits before determining that a site is unoccupied. Given the relatively high detection probabilities, any combination of 3 day and night visits would provide a greater than 88% detection probability of either a single or pair. The initial visits are made during the day and if occupancy is not ascertained, follow ups are made during the night. Additional surveys will be conducted to determine fecundity.

Marin County monitoring mark-recapture data from 1998 to 2003 were included in a range-wide demographic analysis that estimated apparent survival rates for the Marin County study, which were stable relative to other study sites and the sex-specific fecundity. Data collected from 2004 suggest a stable populations and fecundity but statistical analyses have not yet been completed.

Research conducted by PRBO Conservation Science in Marin County using NSO data collected in part by this monitoring program looked at prey availability, habitat selection, and conservation threats. Habitat modeling suggested that protecting intact forested watersheds is a higher priority for protecting the NSO population in Marin County than managing for particular forest types or age classes in the region. In addition, a study on nest sites indicated that 91% of the nests in surveyed in Marin County were platform nests and 9% of nests were in cavities. In contrast, 80% to 90% of nests were in cavities in older forests in northwestern California and the Olympic Peninsula in Washington.

Barred owls (*Strix varia*) present a growing concern in Marin County. The first barred owls were documented in 2002. The first pair was noted in 2005 and the first successful breeding occurred in 2007 within the study area. Sudden Oak Death also presents a growing problem. A widespread die-off of native coast live oak and tanoak species throughout NSO habitat in Marin County may have long-term impacts on habitat, prey populations, and extreme fire behavior.

# Acknowledgements

S. Allen, Point Reyes National Seashore, and D. Hatch, Golden Gate National Recreation Area began this spotted owl monitoring program in the mid-1990s and have provided unflagging support, seeking NPS base and project funding sources to continue to the monitoring program and initiate studies to further explore the relationship of northern spotted owls to the Marin County landscape. PRBO Conservation Science, Marin Municipal Water District, and Marin Open Space District have been partners in the development and continuation of this monitoring program. T. Gardali and R. Cormier from PRBO have been valuable program members for the last several years.

M. Monroe has provided support for the monitoring through the Muir Woods National Monument's volunteer program and has been a liaison with the east Marin County communities and municipalities. D. George designed the initial database and database handbook. Numerous field techs, volunteers and interns have provided the dedication needed over the years.

In 2004, an earlier version of this document was peer reviewed by and benefited from comments made by three reviewers: R. Gutiérrez, University of Minnesota; P. Happe, Olympic National Park; and R. H. Barrett, University of California – Berkeley.

Preliminary sample design assistance was provided in 2006 through 2008 by G. LeBuhn and E. F. Connor, San Francisco State University, though the University of California CESU (Cooperative Ecosystems Study Unit) agreement.

University of Idaho completed the final power analyses and recommended sample design. We are grateful to Kirk Steinhorst and especially Leigh Ann Starcevich for the analyses, for reviewing sections of the protocol narrative, and for seeing this protocol through to this point.

# 1.0 Background and Objectives

The mission of the National Park Service (NPS) is "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (NPS 1916). To uphold this goal, in 1992, the NPS began development of a national policy to better understand the dynamic nature and condition of natural resources, to detect or predict changes that may require intervention, and to serve as reference points for more altered parts of the environment (NPS 1992). In 1998, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) includes Eugene O'Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles National (PINN) Monuments, Point Reyes National Seashore (PORE), and Golden Gate National Recreation (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of SFAN is to monitor a balanced and integrated "package" of vital signs that meets the needs of current park management and will also be able to accommodate unanticipated environmental conditions in the future.

In 2005, SFAN biologists and cooperators completed a vital sign selection process to rank the most important natural resources in the network of NPS units (Adams et al. 2006). The SFAN used four criteria to rank indicators: ecological significance, management significance, legal mandate, and cost and feasibility. Northern spotted owls (*Strix occidentalis caurina*: NSO) represent a vital sign for SFAN due to their ecological significance, a desire to augment to an already large data set on NSO (see Section 1.2), and high interest to the public (Adams et al. 2006). In addition, NPS Management Policies (NPS 2006), the Government Performance and Results Act (1993), strategic plan goals for the NPS, and the Northwest Forest Plan (NWFP; USDA and USDI 1994a, b) require that the NPS monitor long-term status and trends and maintain stable or increasing populations of species listed as threatened or endangered under the Endangered Species Act, such as the NSO.

## 1.1 Northern Spotted Owl Range-wide Status and Habitat Associations

NSOs were listed as federally threatened by the U.S. Fish and Wildlife Service on June 22, 1990 "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990). The owls are distributed in forested regions from southern British Columbia through Washington, Oregon, and northwestern California. They reach the southern limit of their range in coastal California north of San Francisco Bay, where they occur in GOGA, MUWO, PORE, and other parts of Marin County, California (Figure 1).

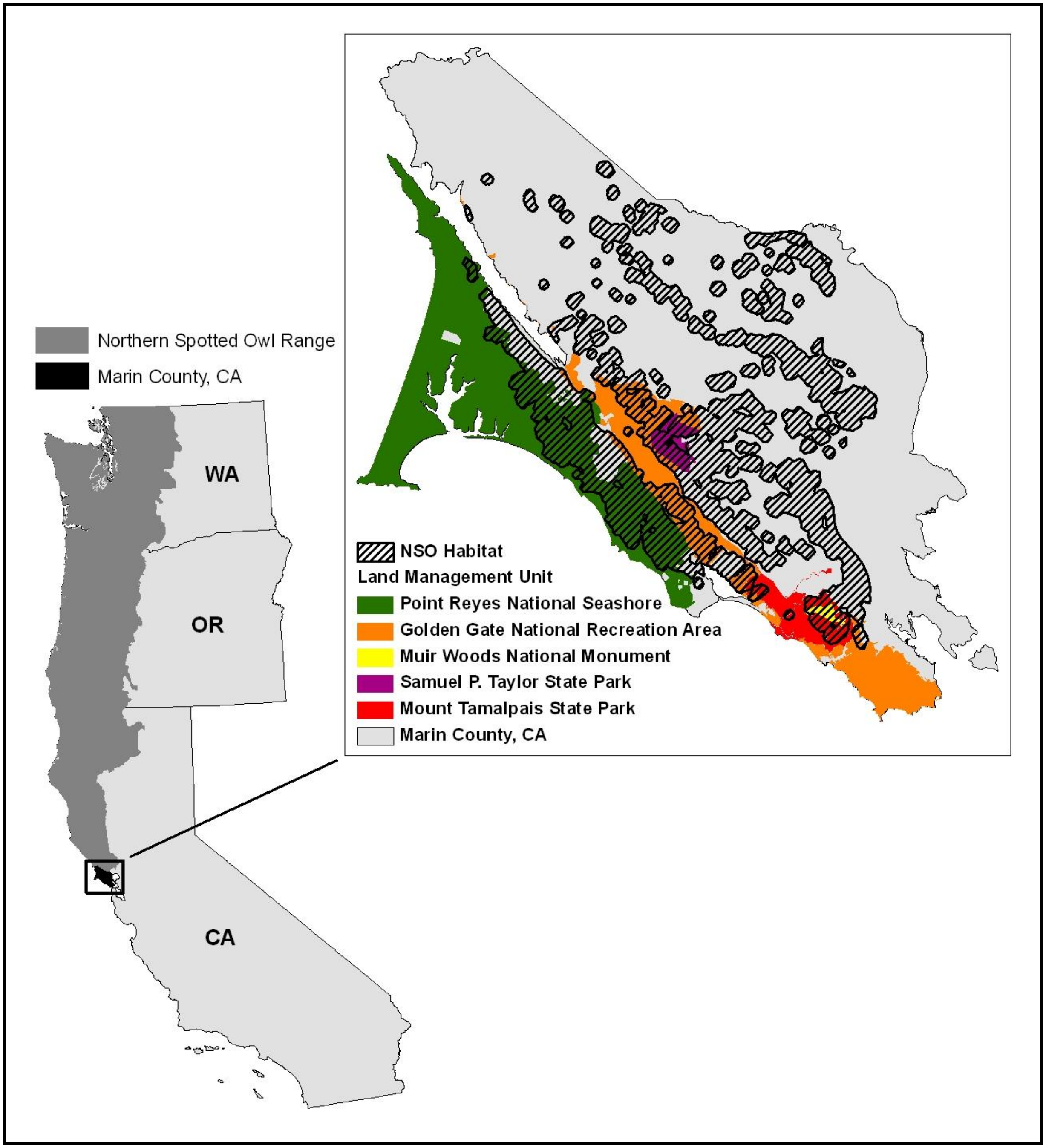


**Figure 1.** NSO suitable habitat (Stralberg et al. 2009) and land management units within Marin County, California.

NSOs are strongly associated with mature and old-growth coniferous forests throughout their entire range (Forsman et al. 1984; Thomas et al. 1990; Carroll and Johnson 2008) because these forests support the features necessary for successful nesting, roosting, foraging, and high prey densities. Important habitat features include a high canopy closure, a complex and multi-storied structure, botanical diversity, a high incidence of potential nest trees and structures, and large accumulations of forest floor woody debris (Thomas et al. 1990).

NSO annual home-range sizes generally increase from south to north, and can exceed several thousand acres in size (Thomas et al. 1990; Zabel et al. 1995). Carey et al. (1992) and Zabel et al. (1995) found that spotted owl habitat use and home range size is related to their primary prey species. In comparison to the northern populations, spotted owls in California may require a broad variety of habitats (Zabel et al. 2003). In the southern portion of the spotted owl range where the dusky-footed woodrat (*Neotoma fuscipes*) is the dominant prey, spotted owls appear to exhibit selective generalist behavior in habitat selection – that is, they select habitats containing a mix of old and younger forest stands that provide adequate nesting and foraging habitats (Zabel et al. 2003).

Several key studies have explored NSO habitat suitability, nest site occurrence, and life history traits (i.e., survival and fecundity) in relation to biotic and abiotic habitat variables at the landscape level. In northwestern California, Franklin et al. (2000) found that NSO survival is positively associated with levels of old-growth forests, and that both survival and reproductive output increase with the length of edge between old-growth forests and other vegetation types. Franklin et al. suggested that "a mosaic of older forest interspersed with other vegetation types promoted high fitness in Northern Spotted Owls". Importantly, Franklin et al. (2000) documented nonlinear habitat relations for NSO, indicating that too much "suitable" habitat may actually have negative effects on NSO requirements, such as foraging. Olson et al. (2004) confirmed a nonlinear habitat relationship in the Oregon Coast Range, reporting that NSO survival was quadratically related to the amount of mid- and late-seral forests within 1,500m of activity centers. As with Franklin et al. (2000), edge effects between older forests and other habitat types also exerted a positive influence on NSOs in the Olson et al. (2004) study, furthering the notion that a mixture of older forests and other habitat types was important to NSO survival and reproduction. More recently, Carroll and Johnson (2008) again confirmed a quadratic relationship between owl sites and old-growth forests in the northern Californian subregion of the NSO range. In the northern regions of the NSO range, however, a more linear relationship between owl abundance and older forests was observed, underscoring the importance of old growth forest preserves in the recovery of NSO populations.

Within the NSO range, trends in NSO populations are evaluated through analyses of demographic data collected in key study areas on private, tribal, state, and federal lands, with some data sets extending back to 1985 (Anthony et al. 2006). Demographic studies include the banding of NSO adults and juveniles, resighting of banded owls, occupancy monitoring of known NSO territories, and reproductive monitoring of nesting NSOs.

The most recent demographic analysis of 14 study areas (Anthony et al. 2006) estimated and evaluated trends in age-specific survival and fecundity rates, and determined annual rates of population change within each study areas and across all study areas. NPS data from Marin County was included in the monograph but excluded from estimates of population change due to low sample size (see Section 1.2.2). Anthony et al. (2006) estimated that NSO populations across the 13 other long-term study areas decreased by an average of 3.7% each year from 1985 to 2003. Owl survival declined in 5 of the 14 study areas, with the sharpest declines reported from all four study areas in Washington. Reasons for these declines in survival and populations likely include, but are not limited to the high densities of barred owls (*Strix varia*) in Washington and

Oregon, loss of habitat due to timber harvest or wildfire, declines in prey abundance, poor weather conditions, and forest defoliation caused by insect infestations (Anthony et al. 2006).

## 1.2 History of Spotted Owl Monitoring in Marin County

The three NPS units in Marin County (GOGA, MUWO, and PORE) began a small-scale, joint NSO survey in the county in 1993. Previously, there had been informal surveys in the area, but only one pair was reported in the NWFP (USDA and USDI 1994a, b). In 1995, after the Vision wildfire, PORE was able to increase survey efforts and initiate monitoring of NSO sites in and around the fire because of an infusion of funds for rehabilitation and environmental compliance (Chow and Allen 1997). Additionally, following the fire, Chow studied NSO density and habitat associations as a graduate student at Humboldt State University (Chow 2001).

### *1.2.1 NSO Inventory*

In 1997 and 1998, recognizing the need for more information about a sensitive species on NPS lands, the NPS conducted a formal NSO inventory study of most federal lands in Marin County using the U. S. Fish and Wildlife Service (USFWS) “Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls” (USFWS 1992) with national NPS funds. The NPS collaborated with PRBO Conservation Science (PRBO) in order to add to the inventory public lands adjacent to NPS boundaries, including Marin Municipal Water District (MMWD), Marin County Open Space District (MCOSD), and California State Parks. The inventory identified at least 80 different NSO territories, or activity sites, throughout Marin County. NSO were found in a variety of forested habitat types, including Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), and mixed hardwood forests comprised of tanbark oak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia)*, and California bay laurel (*Umbellularia californica*). The results of the 1997 and 1998 inventory showed many more NSO activity sites than expected on public lands in the county.

### *1.2.2 NSO Long-Term Monitoring*

In 1999, the NPS and partners began long-term monitoring at 46 of the 80 known NSO territories, identified during the inventory phase on the federal, state, and county managed lands (Hatch et al. 1999). The 46 territories were non-randomly selected based on accessibility, known management issues, and representation of different dominant forest types. Monitoring surveys were conducted to determine reproductive rates and population trends. Monitoring methods followed those of the USDA Forest Service Pacific Northwest Research Station Protocol (PNW) created for use in Northwest Forest Plan NSO demographic study areas (Forsman 1995). These survey methods include repeated calling and feeding of live mice (*Mus domesticus*; known as “mousing”) to enhance detection rates. It has been shown, however, that these methods can alter owl behavior. For example, owls habituated to people or food conditioning may be more vulnerable to disturbance and manipulation by park operations and visitors (Forsman 1995).

In 1999, the NPS modified the PNW demographic study monitoring protocol in response to observed behavioral changes in NSO apparently due to repeated mousing by biologists and photographers. All protocol deviations from the PNW protocol were intended to minimize the number of mice fed to owls by increasing search effort and observation time. The Modified Protocols for Spotted Owl Monitoring and Demographic Studies in Marin County, California

(Marin Modified Field Protocol; Fehring et al. 2001; see SOP 3: Status Designations) increased the search effort and number of visits in order to decrease the number of visits during which mice were offered to owls. Increased search effort was used to determine reproductive variables, including non-nesting status and number of young. Decreased mousing reduced the potential for NSO habituation to people.

The long-term monitoring included a demographic study using mark-recapture techniques to assess population trends. Between 1998 and 2003, the NPS individually marked NSOs at 26 of the 46 long-term monitoring territories using unique color bands and numbered U.S. Geological Survey (USGS) bands (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004). A total of 110 NSOs (37 adults, 23 subadults, 50 juveniles) were banded at the 26 sites. The Marin County study, however, suffered from a small sample size of capture-recapture data. The sample size was small due to banding owls at only 26 activity sites and a small time period of less than five years of recapture data for most banded owls. Despite the limitations of the study results, Marin County capture-recapture data from 1998 to 2003 were included in a range-wide demographic analysis workshop in January 2004 (Anthony et al. 2006). Due to the relatively small sample size compared to the other 13 sites examined in the demography study, the authors were not able to calculate the finite rate of population change ($\lambda$) for the Marin County data (Anthony et al. 2006). The analysis estimated apparent survival rates for the Marin County study, which were stable relative to other study sites (Figure 2) and the sex-specific fecundity (Figure 3).

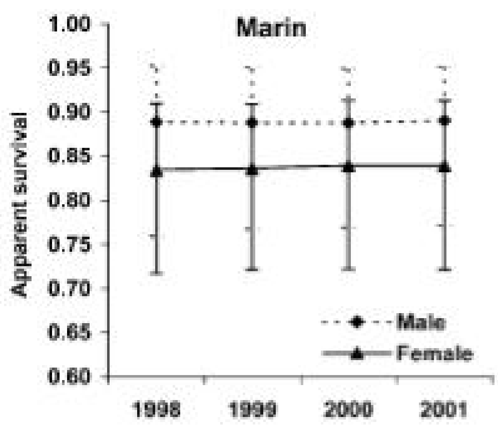


**Figure 2.** Model averaged apparent survival rates with 95% confidence intervals for male and female NSOs in Marin County (adapted from Anthony et al. 2006).

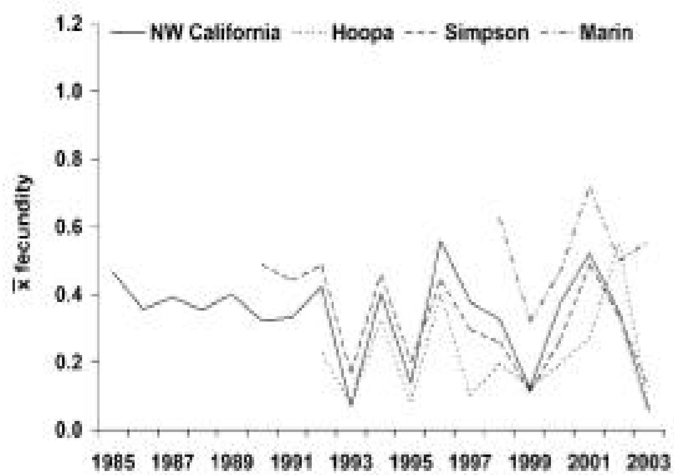


**Figure 3.** Annual fluctuations of mean fecundity (no. female young fledged per female) of NSOs in four study areas in California (adapted from Anthony et al. 2006).

The use of the Marin Modified Field Protocol may have affected estimates of fecundity values during the study, but since the annual fluctuations in fecundity appear to be similar to the other California study areas, we dismiss that as a measurable effect. In all NSO studies, a potential bias in fecundity values is possible due to lower detectability of non-reproducing individuals (Franklin et al. 1996). The reduced use of mice to determine non-nesting in the Marin Modified Field Protocol may have decreased the probability of detecting non-reproducing owls because owls are less habituated to respond to observers. Multiple site visits, though, likely increased the probability of detection. Detection rates of Marin NSOs based on multiple visits were determined to be very high (Connor and LeBuhn 2007c).

Additionally, the Marin County site-based study, with almost 90% annual occupancy of monitored sites does not allow for much growth in occupancy rate to be measured. The general recommendation for the Marin County study from the 2004 range-wide workshop participants was to add more banding sites, add more demographic monitoring sites in suitable habitat, increase juvenile banding efforts and continue monitoring all the sites. Unfortunately, the demographic study ended in 2004 because of limited funding.

In 2004, the program was changed to reduce the level of reproductive monitoring to a random subset of 30 of the 46 long-term monitoring territories (Jensen et al. 2004). The remaining 16 territories were monitored for occupancy only. The number of 30 territories was suggested as a minimum number of sites in order to estimate population fecundity (PRBO, Nadav Nur, Theoretical Ecologist, pers. com. 2004).

Other protocol changes were initiated in 2006 as a result of peer review comments to an earlier version of this protocol. The reviewers emphasized that the selection process for the 46 long-term monitoring territories was not done randomly, which limited the ability to make inferences to the entire population on federal lands. In addition, the high occupancy rate and lack of unoccupied sites within suitable habitat in the sample population limited the ability to detect growth in occupancy.

To address peer review comments and begin modifications to the monitoring design, a formal study area was established and the entire area was inventoried for NSO occupancy in 2006 (Jensen et al. 2007). More details on the study area are provided in Section 2.1. Following the 2006 inventory, all sites were listed under a potential sampling frame for future occupancy monitoring. Only sites with a history of pair status for at least one breeding season between 1997 and 2006 were incorporated into a fecundity sampling frame. From 2007 to 2010, sites were randomly selected for full reproductive monitoring from the fecundity sampling frame (Jensen et al. 2008; Jensen et al. 2010). In 2007 and 2008, 25 random sites were monitored, while in 2009 and 2010 the sample size was increased to 30 random sites annually. The first non-nesting year for NSO was documented in 2007. Monitoring years 2007-2010 were interim years while the program sought statistical support for the occupancy and fecundity data, developed power analyses for the data, developed a final long-term sample design, and worked towards final protocol approval. The final sample design resulting from these efforts is presented in Section 2.0.

### 1.3 History of Spotted Owl Research in Marin County

The inventories and long-term monitoring conducted in Marin County have provided fertile grounds for opportunistic and complementary research.

### *1.3.1 Habitat Associations*

Although typically associated with old growth or mature forests, NSOs can utilize a wide variety of habitat types. They exhibit flexibility in their use of different forested areas for nesting, roosting and feeding requirements, but typical habitat characteristics include a multi-storied structure and high canopy cover. In Marin County, NSOs reside in second growth Douglas-fir, second growth coast redwood, bishop pine, mixed conifer-hardwood, mixed evergreen hardwood forests, as well as remnant old-growth stands of coast redwood and Douglas-fir.

Chow (2001) studied NSO and habitat associations in Marin County between 1996 and 1998 in coordination with NPS inventory efforts (Section 1.2.1). Using a crude density estimate (number of owls per area surveyed), she detected 82 territorial owls at the highest density yet reported for the species (0.376 owls/ $km^2$; Chow 2001; Blakesley et al. 2004). As with other areas within coastal California, NSOs were associated with habitats that had larger trees, greater number of potential nest trees, steeper slopes, and larger proportions of downed woody material. Chow speculated that the high density at the southern edge of the NSO range “reflected a relatively uniform distribution of suitable habitat” and that suitable habitat included mild climatic conditions (2001).

Between 1999 and 2002, PRBO and NPS conducted a more in-depth analysis of NSO occurrence and habitat distribution in Marin County (Stralberg et al. 2009. The study objectives were to apply and evaluate a habitat-based species distribution model, using a scaled approach that would be most useful to land managers.

Model development included a suite of point (i.e., nest location) and landscape features sourced from data collected on site and from locally available GIS layers. Point features included aspect and distances to the nearest stream and road. Landscape features were calculated for circular areas around activity centers at 200 m, 400 m, and 800 m intervals and included slope, elevation, forest cover proportion, proportion of various vegetation cover types (conifer versus hardwood, and specific dominant tree species), forest stand age, and total forest edge.

The analysis benefited from the NPS vegetation map for PORE, GOGA, and MUWO completed in 2003 (Schirokauer et al. 2003). The vegetation map represents an intensive effort involving initial pilot sampling of vegetation communities, manual GIS digitizing of vegetation polygons based on a set of 1994 aerial color photographs, and field verification at over 1,600 vegetation plots. Vegetation types were classified at a fine scale to the alliance/association level resulting in 87 identified plant communities. Classification accuracy of dominant forest and woodland cover types was uniformly robust at 80% or greater (Schirokauer et al. 2003).

Besides the importance of forest cover, the Stralberg et al. (2009) models indicated that forest connectivity and topographic conditions, such as slope position and stream proximity, were the strongest predictors of nesting owl presence. Topographic preferences may reflect a variety of factors, including favorable ambient temperatures, higher prey density, greater nest structure availability, and increased cover and protection from predators. In contrast to other studies within the NSO range, forest type (i.e., conifer-dominated versus hardwood-dominated), specific tree species composition, and mean stand size were not major influences on owl site suitability within the study area. Model results indicate that Marin County NSOs are generalists in this part of their range and may benefit from a high interspersion of forest types within the study area, representing ideal conditions for high prey densities. The authors suggested that protecting intact forested watersheds is a higher priority for protecting the NSO population than managing for particular forest types or age classes in the region (Stralberg et al. 2009). A GIS-layer representing a model of the most likely NSO habitat in Marin County was produced in the study.

### *1.3.2 Nest Structures*

Between 1999 and 2008, 101 unique nests were located within the NPS study area; 91% of the nests were platform nests and 9% of nests were in cavities (Jensen et al. 2010). The ratio of nest types in Marin County is similar to the ratio observed in other younger aged forests such as the Wenatchee National Forest on the east slope of the Cascade Mountains in Washington (Buchanan and Irwin 1993). In the Wenatchee study, 16.5% of nests were cavities, while in older forests in northwestern California and the Olympic Peninsula in Washington, 80% and 90% of nests were in cavities, respectively (Forsman and Griese 1997; LaHaye and Gutiérrez 1999). LaHaye and Gutiérrez (1999) hypothesized that nest type depends on the age of the forest and this is supported in Marin County where logging created a younger-aged forest habitat.

### *1.3.3 NSO Prey*

In the northern portion of their range, NSOs feed on northern flying squirrels (*Glaucomys sabrinus*), but in the southern portion their diet is principally dusky-footed woodrats (*Neotoma fuscipes*). Additional prey items include mice (*Peromyscus* spp.), red tree voles (*Phenacomys longicaudus*), red-backed voles (*Clethrionomys* spp.), brush rabbits (*Sylvilagus bachmani*), pocket gophers (*Thomomys* spp.), and a variety of birds, amphibians and insects (Thomas et al. 1990). Pellet analyses indicate that spotted owls in Marin County forage primarily on dusky-footed woodrats, deer mice (*Peromyscus maniculatus*), and meadow voles (*Microtus californicus*) as well as other small mammals and forest-dwelling birds (Chow and Allen 1997, 2005; Fehring 2003; Fehring et al. 2003).

In the fall and winter of 2002, PORE and PRBO conducted a follow up study to confirm the relative importance of dusky-footed woodrats as a NSO prey species and to assess woodrat house densities in forested habitats. The results of the study showed an overall average of 0.95 woodrat houses per hectare across all plant communities, with California bay (*Umbellularia californica*) habitat having the highest density (1.19 houses/ha; Fehring 2003). Assuming a winter occupancy rate of 1:1 ratio of woodrats to houses, the house index would suggest that there were an average of 0.95 woodrats/ha in the Marin County study. The estimate is conservative since using woodrat houses may provide an underestimate of actual density, because not all houses are likely detected and woodrats will sometimes not use houses. The Marin County woodrat density values were similar to 0.9 woodrats/ha estimated from a density study based on direct woodrat trapping in late seral, mixed evergreen forests in northwestern California (Ward et al. 1998). The Marin County woodrat density estimates were higher than the 0.41 woodrats/ha density found in a woodrat trapping study in large, old growth habitat in northwestern California (Sakai and Noon 1993).

## 1.4 Conservation Threats

The NSO was originally listed as a threatened species because of loss of habitat, reduction in quality of habitat, and inadequate regulatory mechanisms (USFWS 1990). The 2004 status review identified the effects of past and current timber harvest, loss of habitat to fire, and barred owls as current major threats, though the effects of barred owls on NSO remained uncertain (Courtney et al. 2004). In addition, Courtney and Gutiérrez (2004) identified West Nile Virus and Sudden Oak Death (SOD) as new potential threats. The 2008 NSO Recovery Plan acknowledged that protecting and managing NSO habitat alone is not adequate for NSO recovery and the USFWS prioritized barred owls as a significant and complex threat (USFWS 2008). Barred owls overlap in territory and diet with NSOs throughout much of their range, and barred owls are suspected of displacing the smaller NSO (Hamer et al. 1994, 2001; Leskiw and Gutiérrez 1998; Kelly et al. 2003).

In Marin County, the NSO population is subject to some of these same threats. The greatest concerns for the NSO population on federal lands in Marin County, include: (1) loss of habitat resulting from urban development along open space boundaries, (2) catastrophic wildfires, (3) interspecific competition due to the continued range expansion of the barred owl, (4) structural changes in forest heterogeneity due to SOD, (5) possible genetic isolation, (6) human disturbance due to intense recreational pressures, (7) use of rodenticides along the urban/wildland interface, and (8) West Nile virus.

### 1.4.1 Barred Owls

In May 2002, the first recorded barred owl observation for Marin County occurred within a monitored NSO territory at MUWO. The first barred owl pair was detected in 2005, and the first successful breeding by barred owls was documented in 2007, also in MUWO (Jensen et al. 2008). No spotted owl/barred owl hybrids have been documented to date. As of 2009, there are currently at least three known barred owls (one pair and a single male) within the NPS NSO study area in Marin County (Jensen et al. 2010). Four spotted owl sites selected for monitoring within the resident male barred owl's Olema Valley territory were determined to be unoccupied during the 2008 breeding season.

### 1.4.2 Sudden Oak Death

Of particular recent concern are the effects on NSO habitat of continuing die-off of tanoaks, coast live oaks and several other tree and shrub species due to a pathogen, *Phytophthora ramorum*, commonly known as Sudden Oak Death (SOD). This disease is widespread in coastal California and is commonly found in tanoaks, and in evergreen hardwood forests dominated by oaks, California bay, and madrone (*Arbutus menziesii*). Currently, Marin County is heavily infested by SOD. A recent study of PORE vegetation by researchers from University of California at Berkeley (Moritz et al. 2008) sampled SOD at 48 locations within three major vegetation types: redwood-tanoak, Douglas-fir, and California bay-coast live oak. Additionally, foliar samples were taken at 74 locations. Of these foliar sampling locations, 29 (39%) tested positive for *P. ramorum* and the pathogen was found in all three major vegetation types sampled. From the proportions of the randomly located plots that tested positive for infection, the researchers inferred that as much as 63% of redwood-tanoak forests, 45% of California bay-coast live oak forests, and 24% of Douglas-fir forests at PORE may be infected with *P. ramorum*. In several plots, tanoak mortality was greater than 95%. Finally, Moritz et al. (2008) stated that because tree species richness is low within their sampled locations, tanoak represents a substantial proportion of tree species richness and total woody species richness in both redwood and Douglas-fir forests. Consequently, if tanoak is eliminated by SOD, as scientists predict, the tree species richness of redwood forests could be locally reduced by as much as one-third.

The die-off of native coast live and tanoak species is occurring throughout NSO habitat in Marin County, and this may have long-term impacts on habitat and prey populations. The major NSO prey species, the dusky-footed woodrat (Chow and Allen 1997, 2005; Fehring 2003), is dependent upon cover and food (acorns) provided by tanoaks (Sakai and Noon 1993). There are no published studies on the effects SOD on NSO prey base and this is a pressing research need for land management agencies in Marin County.

Oak mortality induced by SOD also causes changes in fuel loading, stand structure, and microclimate. As these changes occur, the potential for uncharacteristically extreme fire behavior and associated ecological impacts likely will increase. Anecdotal reports from fire fighters working in redwood forests infested with SOD during the 2008 Basin Fire in Big Sur, California indicated increases in fire intensity of approximately 25% (Lee et al. 2009).

### *1.4.3 Genetic Isolation*

Feather samples collected in 1999 and 2000 from Marin County's NSO population were part of a study conducted at the Conservation Genetics Laboratory at San Jose State University. The Conservation Genetics Lab compared the Marin County NSO population with other populations of northern and California spotted owls (*Strix occidentalis occidentalis*). Their results indicated that the Marin County NSO population has very little gene flow with NSO populations farther to the north and shows no evidence of hybridization with California spotted owls (Henke et al. 2003; Barrowclough et al. 2005). Henke et al. (2003) did not find evidence of inbreeding effects in the Marin County NSO population, but Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's NSO population, the population warrants special management attention.

### *1.4.4 Predation*

Predation is not believed to be an important threat within Marin County, but common ravens (*Corvus corvax*) and other corvids are suspected predators of NSO eggs. Range-wide NSO predators also occur in Marin County and include northern goshawk (*Accipiter gentilus*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*) (Forsman et al. 1984; LaHaye 2004).

## 1.5 Measurable Monitoring Objectives

There are three current monitoring objectives for the SFAN NSO Monitoring Program. The methods are outlined in the sampling design and field methods sections below.

1. Monitor long-term trends in NSO site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.

2. Monitor long-term trends in NSO fecundity (number of female young per territorial female) within NSO territories within the legislated NPS boundaries of Marin County, California.

3. Determine long-term trends in NSO nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

Monitoring NSO population occupancy rates and fecundity will allow managers to accurately assess the status and trend of this isolated, potentially vulnerable NSO population, where it occupies a land use matrix strikingly different from that found throughout most of the NSO range. An analysis of historic fecundity data in the Marin County NSO monitoring program indicates that fecundity is a valuable parameter to measure for population size declines (Connor and LeBuhn 2007a, 2007b). Percent of occupied territories has been shown to be a good indicator of long-term declines in population size in a territory-based monitoring program for other raptors (Bart and Robson 1995; Katzner et al. 2007). Additional information collected at all activity sites will include sex and age of all NSOs. Concurrent monitoring of nest site characteristics may provide data on reasons for changes seen in reproductive success and also allow assessment of possible changes in nest site selection and/or differences in habitat quality.

Demographic monitoring to estimate rates of survival and population growth is occurring on late-seral stage forest reserves throughout the NSO range as part of the Northwest Forest Plan monitoring. While conducting demographic monitoring in Marin County would be ideal to better pinpoint changes in the NSO population, it is not feasible given current funding limitations.

## 1.6 Management Objectives

NSO monitoring provides critical data for land managers. Occurrence and nesting status information is frequently used by the parks to plan and mitigate for activities that may create potential nest or habitat disturbances. Fuel-load management, roads and trails maintenance, and other construction activities, for example, are generally not planned within 400 m of active nest sites or during the February 1 to July 31 seasonal restrictions window currently used by the USFWS (USFWS 1992).

Federal land in Marin County is included in the USFWS 2008 Recovery Plan as a Managed Owl Conservation Area (MOCA 2) which is defined as a small habitat block that can support between 1 and 19 NSO pairs based on the USFWS habitat modeling. USFWS Recovery Action 2 is to continue monitoring the population trend of NSO to determine if the population is decreasing, stationary, or increasing. While demographic monitoring is currently the primary action to assess the population status in other NSO areas, the monitoring methods in this protocol are designed to address the potential decline in the NSO population within the Marin County MOCA 2. The non-federal lands in Marin County (i.e., MMWD, MCOSD, and state parks) are identified as a Conservation Support Area (CSA). CSAs may function to provide demographic support to core NSO populations in the MOCA network or facilitate dispersal of juvenile NSO among MOCAs (USFWS 2008). In most cases, the CSA designation also recognizes existing land management that is compatible with the NSO recovery goals (USFWS 2008).

Given that NSO are a federally listed species, the Marin County NSO habitat is identified in the NSO Recovery Plan, and NSOs have high public interest, the SFAN parks have strong management interest in continuing NSO population trend monitoring on park lands in Marin County. Also, through monitoring NSO, biologists expect to also detect the presence of barred owls within the study area. While the number of barred owls is still very low, increased detections are of great interest to park managers because of their potential threat to NSO.

### 1.7 Triggers for Management Activities

The target management triggers for the NSO are as follows:

- A 4% annual decline or greater in pair occupancy in 5 consecutive years of monitoring.
- A 10% annual decline or greater in fecundity in 5 consecutive years of monitoring.
- A decline in fecundity and/or occupancy of >50% in 2 consecutive years of monitoring.
- Reproductive failure for 3 out of 6 years.
- Barred owls are documented at >10 spotted owl sites in any given year.

Thresholds for NSO occupancy and fecundity reflect the results of power analyses of the long-term monitoring data (see Section 2.2). The threshold levels represent the number of years to detect 4% and 10% compounded annual changes with greater than 80% power. A 4% annual decline over 5 years therefore represents a 15% cumulative decline. A 10% annual decline over 5 years represents a 34% cumulative decline. The power analyses indicate that our current monitoring design has the ability to detect significant population changes in short periods of time, thus allowing for timely, reactive management actions if warranted.

Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol. In some cases, causes of declines in the NSO population, such displacement by and competition with as barred owls, may be easy to identify. If causes of population declines can be determined, managers may be able to act accordingly in a timely manner. In other cases, however, additional, specific research may be required. Depending on the management action(s), a procedural process under the National Environmental Policy Act may be instigated, requiring significant public input. Consultation with USFWS and other regulatory agencies may also be required especially when there are any catastrophic declines in fecundity and/or occupancy, repeated reproductive failure, or increases in barred owls. Although the SFAN will provide data and guidance, management actions will ultimately be decided by PORE, GOGA, and MUWO management staff, including, but not limited to, the park Wildlife Biologists, Science Advisors, Chiefs of Resource Management, and Superintendents.

# 2.0 Sampling Design

While demographic monitoring in Marin County would be ideal to detect a variety of changes in the NSO population, it is not feasible given current funding limitations. Occupancy monitoring, when combined with detection probabilities, may be the most cost-effective means to detect population trends, long-term effects of barred owls, or other threats to the NSO population on federal lands in Marin County. Measuring fecundity using the same methods as other NSO studies will provide some regional context to relate possible changes in Marin County to range-wide trends.

While annual monitoring is ideal for any long-term monitoring program and provides the most powerful sample design, limited resources require constrained field efforts. Decisions about monitoring efforts must be made within a framework that considers acceptable objectives in addition to funding, personnel, and management needs.

It is recognized that some additional monitoring may be needed annually to help answer management questions. For example, scheduling annual trail maintenance or periodic trail restoration may require repeated site surveys to determine NSO occupancy status before initiating work within NSO habitat. Surveys done for management purposes may be incorporated into the monitoring database and reported.

## 2.1 Study Area and Site Selection

The study area is approximately 13,890 hectares (34,320 acres; Figure 4) of federal lands in Marin County and includes sites at GOGA, MUWO, and PORE. The study area boundaries were created through a GIS analysis, using the area intersected by the 2003 buffered habitat model layer (Stralberg et al. 2009) and a 400 m buffer on federally legislative boundaries of GOGA, MUWO, and PORE. All NSO territories surveyed during inventory years in 1997, 1998, and 2006, regardless of results, were selected as the potential sample population or population of inference (n= 66) for occupancy and fecundity monitoring.

A total of eight territories were removed from the potential sample population. The sites were eliminated due to private landownership (i.e., Drake’s View Drive area, Inverness Valleys, Paradise Valley), unsafe access (i.e., steep terrain on slopes of Mount Tamalpais), or duplication of other sites (i.e., sites too close to be separate and distinct activity sites but which had been assigned different names).

Upon reviewing the list of sites not selected in the GIS analysis, two territories were added back into the potential sample population. These two territories had not been selected in the GIS analysis because the activity sites were outside of the buffered habitat model, but still within the buffered federal land boundary.

Note that locations of these sites are considered sensitive information and are not provided within the protocol and standard operating procedures. GPS locations of the selected sites, however, are maintained within the project database.

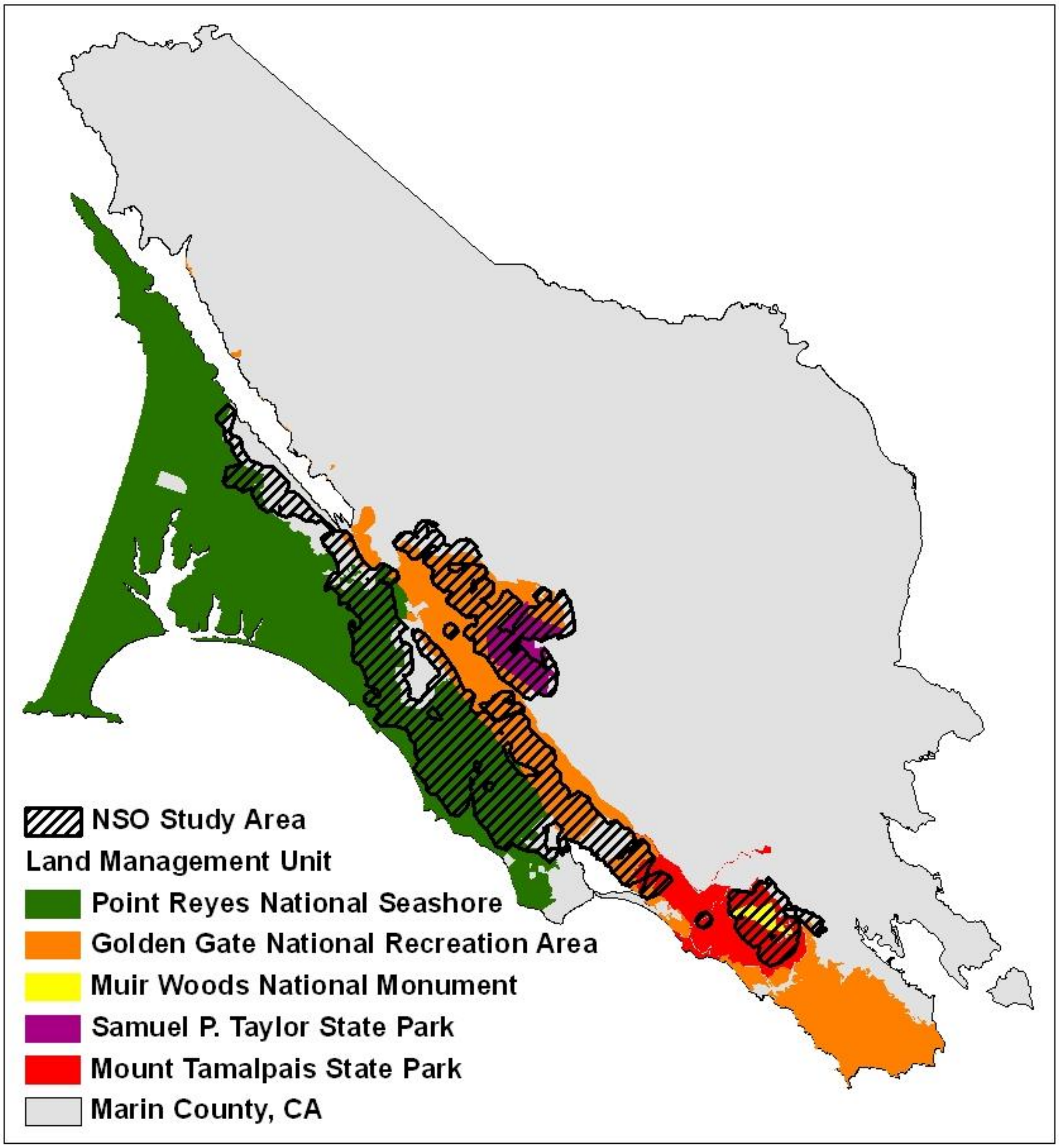


**Figure 4**. Northern spotted owl study area. Marin County land management units are color coded. The study area itself is shaded in black, diagonal lines.

## 2.2 Sample Design Power Analysis

Sample design analyses considered a broad range of options in order to evaluate different trend detection levels, sample sizes, cycling options, and staffing plans. The goal of the analyses was to determine the most cost-effective means to detect significant trends within a short-time frame and to provide inference to the entire study area rather than a fixed subset of the study area's NSO population. An initial review of our NSO monitoring data with recommendations for sample sizes needed to detect trends over time was conducted by San Francisco State University in 2007 (Connor and LeBuhn 2007a, 2007b, 2007c). In 2010, a more refined approach to our monitoring data was completed by the University of Idaho (Starcevich and Steinhorst 2010), which incorporated additional years of data and barred owl presence as a covariate for occupancy and detection modeling. The final report of the power to detect trends in occupancy and fecundity in the study area's NSO populations is included within the protocol as Appendix A.

### *2.2.1 Occupancy Analysis*

All locations within the final study area (see Section 2.1) that had an NSO detected at any time between 1997 and 2008 (60 sites) were included in the potential sample population for monitoring occupancy. These sites, known as the occupancy frame, were used to model the power to detect trends in occupancy over time for a series of sample designs (Appendix A). However, not all territories have been consistently or are currently occupied.

Occupancy was modeled with logistic regression as a function of related covariates, including site and year. The implicit dynamics occupancy model was assumed for the analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

The model for occupancy incorporated zero inflation. For occupancy, extra zeroes may result from imperfect detection. Analysis methods for zero-inflation apply mixture models that combine one distribution for the extra zeroes and another distribution for the remaining zeroes and non-zero outcomes so that measures of occupancy and fecundity can be accurately estimated (MacKenzie et al. 2006). The number of detections for occupancy analysis was modeled as a zero-inflated binomial random variable.

Maximum likelihood was used to estimate the logistic regression coefficients from the models for occupancy and detection rates. Detection probabilities were allowed to vary at each visit for each site and year, as covariates are often environmental or survey conditions that vary from visit to visit (MacKenzie et al. 2006). The models for NSO occupancy rate included covariates for year, and barred owl detections, and the detection rate model included covariates for the time of survey (day versus night), call method (yes versus no), and number of observers.

Model selection was conducted using the Akaike Information Criterion (AIC). Model output was examined to be certain that valid variance estimates are obtained. When valid estimates of the variance could not be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance was used for trend testing.

One of six possible occupancy status categories is assigned for each location monitored each year. These occupancy categories are mutually exclusive, with all locations falling into only one category each year. Ultimately, the most appropriate occupancy model would estimate occupancy trends for all status categories simultaneously so that the sum of occupancy estimates across categories is always one. However, the available literature has not incorporated techniques for estimating occupancy for more than two categories with methods for trend estimation. A univariate approach was taken to model the occupancy categories, however, only the pair occupancy category provided a meaningful ability to detect trends over time.

Fixed and random effects for location were examined in the modeling effort for occupancy and detection rates. Adding a fixed effect for location prohibitively reduced the number of degrees of freedom available for error estimation. Modeling the location effect as a random effect in the detection model produces the heterogeneous detection probability model which is often difficult to implement in a maximum likelihood approach (MacKenzie et al. 2006). In practice, this approach resulted in site-by-year level occupancy estimates very near 1 and with nearly zero variation and corresponding detection probabilities very near zero. Incorporating the random effect into the occupancy model produced similar problems.

The benefit of incorporating a fixed or random effect for location is that repeat visits to the same locations over time can reduce variance and provide more accurate trend estimation. Without a location effect, the data are treated like random samples taken independently each year (a [1-n] revisit design), no matter what revisit design is actually implemented in the field. The [1-n] revisit design has the lowest power for trend detection and therefore provides conservative power results.

Hypothesis testing for trend was conducted with the likelihood ratio test. The occupancy model that included a year term was compared to the occupancy model without a year term. A one-sided test for a decreasing trend was examined.

### *2.2.2 Fecundity Analysis*

For the fecundity analysis, only territories that have had a pair of owls present at some time between 1999 and 2008 (48 sites) were included in the potential sample population for fecundity analysis. These sites, known as the fecundity frame, were used to model the power to detect trends in fecundity over time for a series of sample designs (Appendix A).

Fecundity was monitored with counts of NSO fledglings observed at each nest. As with the occupancy analysis, these outcomes were also modeled with the zero-inflated binomial model. When measuring fecundity, counts of fledglings might be subject to zeroes from nest failures due to non-nesting pairs, predation, or environmental factors.

Maximum likelihood estimation was used to obtain estimates of the regression coefficients in each model. To test for trend in fecundity, the year covariate was included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change probability of a fledgling at a site in a year over time.

### *2.2.3 Power Analysis*

The occupancy and fecundity models with the lowest AIC scores and with a valid variance-covariance matrix were used in the power analysis. In both cases, power was computed via a parametric bootstrap. For each bootstrap sample, the likelihood ratio test of trend was conducted by applying the selected model with and without the term for trend. Power was then calculated as the proportion of times that the null hypothesis is rejected for the one-sided alternative hypothesis of decreasing trend.

Power must be approximated assuming that tests of trend are conducted at a specific Type I error rate. The Type I error rate, designated as α, is the probability of rejecting a true null hypothesis. For the one-sided test of trend, a Type I error would mean that the population was found to be declining when it was not. A Type II error occurs by failing to reject a false null hypothesis and thus concluding no change has occurred. For long-term monitoring, the cost of a Type I error may be far less than the cost of a Type II error. Mistakenly rejecting a true null hypothesis (Type I error) may trigger a management conservation action that is not actually needed. However, failing to detect a significant declining trend may have deleterious effects that cannot be reversed by the time the trend is actually detected. A conservative approach is to use a larger α value for higher power and reduced probability of a Type II error. For this power analysis, an α value of 0.20 was used.

## 2.3 NSO Monitoring Design

The SFAN I&M Program has selected a sample design for NSO occupancy and fecundity monitoring that surveys 36 sites each year. The design includes an annual panel of 28 randomly selected sites with all remaining sites divided equally into four rotating panels of 8 sites each (Table 1). Following the notation of MacDonald (2003), this revisit schedule of [(1-0), (1-3)] indicates that the annual panel is revisited every year and that the four panels are visited for one year then not visited for the following three years before being rotated back into the design. Under this revisit design, all 60 NSO territories with the SFAN study area will be monitored within a four-year time frame, or a single rotation of the sampling design.

**Table 1.** Selected sample design for NSO monitoring. The [(1-0), (1-3)] revisit design includes an annual panel of 28 sites with four rotating panels of 8 sites each. An example schedule for two monitoring cycles over eight years in displayed (Starcevich and Steinhorst 2010).

| Panel | Revisit design | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | [1-0] | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| 2 | [1-3] | 8 | | | | 8 | | | |
| 3 | [1-3] | | 8 | | | | 8 | | |
| 4 | [1-3] | | | 8 | | | | 8 | |
| 5 | [1-3] | | | | 8 | | | | 8 |
| ANNUAL TOTAL | | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |

Site occupancy will be established at all 36 territories monitored each year. Fecundity determination will occur at every site occupied by a territorial female, no matter if the site is within the annual panel or one of the rotating panels. Similarly, nest tree characteristics will be recorded for every nest detected during monitoring. Geographic coordinates of occupied sites, which default to nest locations for nesting pairs, in addition to nest tree and site measurements will provide a foundation for understanding NSO habitat relations over time.

No physical site stratification will used in establishing the monitoring sites included in the annual panel. The selected territories are expected to represent a variety of forest types, slopes, watersheds, and soil types. Random selection of sites will be made by using a random number generator to assign a random number to each site, ordering the list, and selecting the first 28 sites for monitoring.

Starcevich and Steinhorst (2010) recommend that 20 to 25 locations with resident females must be surveyed annually to detect decreasing trends in fecundity of at least 10% within 5 years (Appendix A). Monitoring data indicates that from 1999-2009, approximately 70% of the NSO territories monitored resulted with a territorial female and a subsequent fecundity value for the monitoring season. The selected revisit design therefore oversamples for fecundity monitoring with the prediction that only 70% of sites will be available for fecundity analysis each year. With 36 sites monitored annually, a 30% reduction in available sites for fecundity monitoring results in approximately 25 available sites, which is still a large enough annual sample size to detect the targeted trend of a 10% annual decline over 5 years with at least 80% power.

To further ensure that the annual sample size is large enough to detect trends in fecundity over time, the annual panel of 28 sites will be comprised solely of locations included in the fecundity sampling frames, which are those sites occupied by a NSO pair during at least one breeding season from 1999-2008. We will randomly select the 28 annual panel sites from the list of sites within the fecundity sampling frame. The remaining sites within the study area will be randomly allotted to the four rotating panels. If needed, the sites included in the occupancy frame but not the fecundity frame could be balanced among years in the rotating panels, thus balancing the sites where NSO have been detected but where pair occupancy has not been established.

The power analysis conducted by Starcevich and Steinhorst (2010; Appendix A) indicates that the selected sample design has a power of 0.992 (99%) to detect a 4% annual decline in occupancy in 5 years with $\alpha = 0.10$, and 1.000 (100%) with $\alpha = 0.20$ (Table 2). Over 5 years, a 4 % annual decline results in a total of a 15% loss.

Additionally, the results of the power analysis suggest that an annual sample of greater than 20 fecundity sites, as will be achieved with the selected sample design, will result in greater than 80% power to detect a 10% annual decline in fecundity in 5 years with $\alpha = 0.20$ (Figure 5). Over 5 years, a 10 % annual decline results in a total of a 34% loss.

**Table 2.** Power of the likelihood ratio test to detect trends in spotted owl pair occupancy within five consecutive survey years for four revisit designs (Starcevich and Steinhorst 2010).

| Revisit design | Power to detect a 4% annual decrease in occupancy | | Power to detect a 10% annual decrease in occupancy | |
|---|---|---|---|---|
| | $\alpha = 0.10$ | $\alpha = 0.20$ | $\alpha = 0.10$ | $\alpha = 0.20$ |
| $[(1\text{-}0)^{15}, (1\text{-}3)^{1/2}]$ | 0.980 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{26}, (1\text{-}3)^{1/2}]$ | 0.992 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{28}, (1\text{-}3)]$ | 0.992 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{40}, (1\text{-}3)]$ | 0.996 | 1.000 | 1.000 | 1.000 |

### *2.3.1 Sampling Frequency and Timing*

Generally, survey visits must occur within the breeding season time period of March 1 to September 1 when NSOs demonstrate the highest degree of territoriality and vocal response to artificial calls (USFWS 1992; Forsman 1995). Technically, a survey area can be considered "occupied" if at any time throughout the year a NSO is detected, but assigning a level of occupancy, nesting, or reproductive status must occur within the breeding season. Standard operating procedure SOP 2: Field Survey Procedures describes more detailed timing guidelines

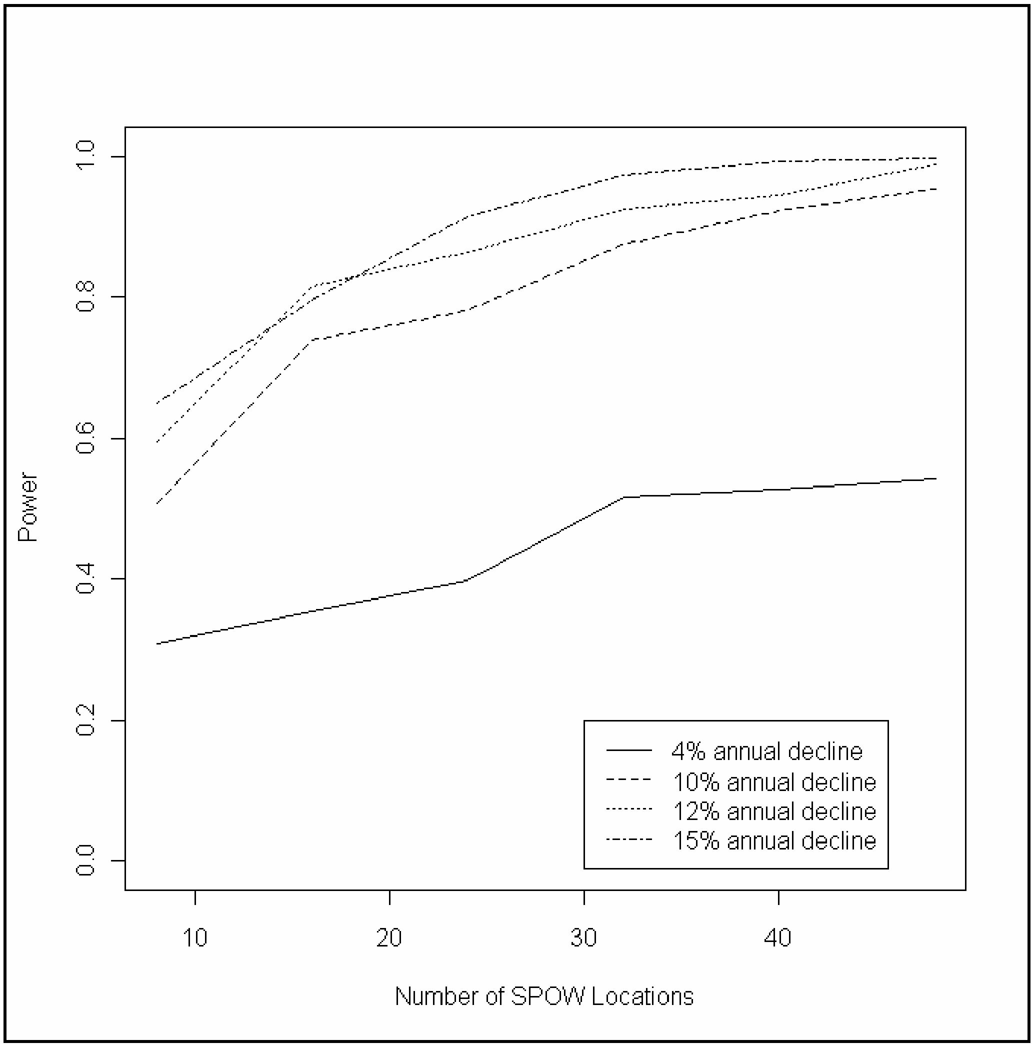


**Figure 5.** Power of the likelihood ratio test to detect trend in the binomial probability of spotted owl fecundity in 5 consecutive survey years for four rates of change (Starcevich and Steinhorst 2010).

and number of surveys required for ascertaining certain types of information (e.g., nesting status, fledgling counts) within the breeding season period.

In 2007, San Francisco State University conducted an analysis of day versus night detection of NSO singles and pairs using NPS data from 1999-2005 (Connor and LeBuhn 2007c). Using the lowest annual probabilities of single owl detection for day and night (night=0.67 and day=0.76), Connor and LeBuhn estimated that sampling NSO sites twice during the day and once at night provided a 98% probability of detection of at least one NSO. The probabilities of detecting a pair of owls were 0.50 for both day and night. Given the relatively high detection probabilities, any combination of 3 day and night visits would provide a greater than 96% probability of detection of at least one NSO and an 88% detection probability of an NSO pair.

## 2.4 Sample Design Review

The effectiveness of the NSO monitoring design to detect target trends in occupancy and fecundity will be evaluated through long-term trend reports produced by the SFAN, which are scheduled for completion at five-year intervals. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. In addition, the long–term effect of SOD is still unknown, but significant impacts on suitable NSO habitat are possible. A precipitous drop in site occupancy rate may suggest that owls are leaving the study area, moving further outside of their historic activity centers than our field monitoring protocols can capture, or are dying for reasons unknown. Reanalyzing the detection rates using new data, reassessing our current NSO habitat model (Stralberg et al. 2009), completing another full study area inventory, and revising the field methods are possible responses.

In a study of changes in NSO response to NSO playback calls, Crozier et al. (2006) found NSOs responded less frequently to NSO calls after being exposed to barred owl calls. As the barred owl population in Marin County is expected to increase, the annual sampling frequency and field protocols may need to be adjusted to increase the number of surveys per territory and widen the search area requirements. An interagency Barred Owl Work Group and its Survey Protocol Subcommitte, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

## 2.5 Additional Surveys

Each year, project staff or cooperators survey 15 to 30 additional NSO territories throughout Marin County, primarily to address specific management concerns. Most of these additional sites are outside the study area covered by this protocol and on lands owned by MMWD and MCOSD, who provide funding and support for the surveys conducted by PRBO staff. The NPS may include additional monitoring sites each year if sites with management concerns, for example sites that may be affected by road or trail maintenance, are not included in the annual monitoring sample. These sites also serve to expand the probability of resighting banded owls that have relocated out of the NPS study area, as well as detecting any barred owls, West Nile Virus or SOD in the areas. The core monitoring objectives do not include monitoring sites or areas strictly for direct management purposes, such as in preparation for trail or road work in NSO habitat. While these additional NSO surveys are outside of the parameters of this monitoring program, the results from outside of the study area may serve to provide an early warning to NPS managers of threats to the Marin County NSO population that have not yet manifested within NPS boundaries.

# 3.0 Field Methods

The NSO field season runs from approximately February to the end of August. Surveys are conducted March 1 to July 31. Data are entered into the database throughout the field season. Additional time at the end of the field season is used to analyze data and report results.

## 3.1 Field Season Preparations

Field technicians are hired and begin by February of each year. Their initial responsibilities will be to gather and check field equipment including binoculars, GPS, calling equipment, etc. All field equipment is listed in SOP 1: Preparations and Equipment Setup Procedures. In addition, a pre-season meeting convenes at the beginning of the field season for all members of field teams to discuss the season priorities, assign territories to field teams, and review protocols. If necessary to train interns or new technicians, a training day is scheduled to further review details of field techniques, protocols and safety procedures. New staff will also be sent out with trained staff until they are familiar with the monitoring protocol and study sites. Each field team is responsible for preparing field maps for each territory/activity center, which will be used in the field and attached to all final search form data sheets. The SFAN Data Manager provides copies of the satellite database to field teams. The satellite database is identical to the master database except that the field data tables are empty. Additional details about field season preparations are provided in SOP 1: Preparations and Equipment Setup Procedures.

## 3.2 Sequence of Events during Field Season

NSO surveys may be conducted from March 1 to September 1. For the purpose of this monitoring program, however, field crews are instructed to complete field work by July 31 to allow enough time to enter and analyze data and complete an annual report. The purpose of the surveys is to establish the occupancy status, presence of territorial pairs, and reproductive status. All monitoring sites in Marin County should be surveyed at least once by April 15 to determine occupancy. All monitoring sites selected for reproductive monitoring should be visited during the period of April 15 to May 1 to determine nesting status, and may require additional visits. Surveys to determine the number of young produced occur as needed during weekly nest checks between May 1 and July 31. Although it is anticipated that all field work will be complete by July 31, difficult sites may require surveys in August in order to finalize occupancy and reproductive status. The survey protocol and field methods are detailed in SOP 2: Standard Field Procedures and SOP 3: Status Designations,

## 3.3 Survey Protocols

Standard field survey protocols guide the primary data collection tasks for monitoring, which are: 1) to locate owls at individual activity centers, and to determine their sex, age and whether they are banded, and 2) determine status; that is, use behavioral observations to determine site occupancy and reproductive success for estimating fecundity rates. SOP 2: Standard Field Procedures provides more details on the standard procedures for night and day activity center monitoring surveys and data collection. SOP 3: Status Designations contains the guidelines for determining annual activity center status based on field data collection results.

### *3.3.1 Activity Center Monitoring*

Activity centers are the focal points of NSO nesting and roosting activity. Within an occupied territory, the actual activity center location on the ground may change from year to year, but pairs of owls typically remain within the same sub-watershed or canyon. Activity center monitoring begins March 1 and continues until occupancy and reproductive success information has been obtained following the standard field procedures (SOP 2: Standard Field Procedures), but survey efforts should end by July 31. In some cases additional surveys may be needed through September 1. At sites that have been previously occupied by NSO pairs, surveyors initially attempt to visually locate the owls at their roost sites during the day without calling to minimize disturbance to the owls. Alternatively, owls are located using recorded playback or vocal imitations of their calls to elicit responses. Day or night surveys are used depending on site conditions. When necessary, surveyors utilize call routes along roads and trails with call points located a minimum of 400 m (0.25 miles) apart, or at the mouth or head of each forested drainage. Calling is conducted for at least 10 minutes at each call point. Off-trail calling is done at intervals along continuous transects.

For most monitoring site visits, it is preferable for efficiency and safety to have more than one person in the field. More eyes and ears allow for more thorough and efficient field visits. The responsibility for taking field notes is assigned to one member of the field team. If members of a team split up during a survey, both members are expected to take notes on their activity and combine the information at the end of the survey. Notes are taken either in field notebooks or directly on the Site Search Field Form (see SOP 2: Standard Field Procedures). The primary note taker is also responsible for entering the data from that site visit into the database and creating a map documenting the site visit. Maps are not required for subsequent nest checks following the first site search resulting in a nest discovery, unless there is a change in the occupancy or reproductive status (e.g., nest failure).

Variables measured annually for monitoring occupancy include number of owls, sex, age and presence/absence of a color band/tab combination. Between 1998 and 2003, 110 owls were captured and color-banded on NPS lands and surveyors continue to visually check and note presence or absence of USGS and color bands for all owls detected.

At the NSO territories selected for fecundity monitoring, the owls are monitored to determine nest success or failure, the number of young produced, and nest tree and habitat variables. All owl activity centers (either nest tree or roost tree location) are recorded in GPS (Global Positioning System) coordinates using a Garmin 3+ or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are later obtained by using ArcGIS 9.3.1 or higher (ESRI 2009).

### *3.3.2 Measuring Nesting Habitat*

All nest trees, except those on private lands, are marked (site number and year) using aluminum tree tags (Forestry Suppliers, Inc.). The tags assist observers in determining old nest trees and tree reuse during monitoring. Nest site measurements include nest tree species, diameter at breast height (dbh), nest tree height, nest type, nest height, and aspect, slope, and relative slope position (low, middle, ridgetop). Dominant overstory and understory species are also recorded. In the office using GIS, three additional habitat variables are calculated: distance to forest opening, distance to water, and distance to forest edge. Details on the procedures and data collection using the Nest Habitat Data Form are found in SOP 2: Standard Field Procedures.

## 3.4 Cooperation with Other Research Activities

NSO monitoring provides information to other ongoing research during regular field activities. Additional information is also in SOP 2: Standard Field Procedures.

### *3.4.1 Documenting West Nile Virus*

Although West Nile Virus (WNV) has not been detected in a non-captive NSO as of May 2008 (USFWS 2008), the virus has been found in captive NSO and in wild barred owls. The likelihood of finding a dead or sick NSO with WNV is low given the brushy locations that are surveyed, but it is possible. Current procedures for handling a sick or dead NSO suspected of having WNV are similar to procedures for other birds except the initial contact would be made to the USGS National Wildlife Health Center (West Nile Virus Coordinator, Madison, WI (608) 270-2456). Additional directions on dealing with bird species found during field work that are suspected to have died from WNV are in SOP 2: Standard Field Procedures.

### *3.4.2 Documenting Sudden Oak Death*

Sudden Oak Death (SOD) has been confirmed in all areas of the study area. *P. ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients (Moritz et al. 2008). Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death. Many other diseases cause similar symptoms; therefore, the presence of *P. ramorum* can only be confirmed by a laboratory test.

During field surveys, researchers should look for tanoaks or coast live oaks showing the symptoms of SOD. Researchers should be familiar with the document "How to recognize symptoms caused by diseases caused by *Phytophthora ramorum* causal agent of Sudden Oak Death" (Garbelotto et al. 2002). If symptoms are noted in previously undocumented areas, researchers should inform both the PORE and GOGA Supervisory Botanists who may conduct further testing to confirm SOD.

A SOD Severity Index will be established at each NSO site monitored each year adapted from rapid assessment methods developed by Moritz et al. (2008). The severity index evaluates affected tanoaks and coast live oaks on a scale of 0 (no SOD present) to 10 (>95% canopy cover). The severity index considers both overstory and understory trees within a circular plot (50 m radius) and includes both dead and symptomatic vegetation. The center point for the SOD severity index rating will be at the established activity centers, such as nest trees, for each NSO site monitored. For sites where a defined activity center is not found or is questionable, field staff may opt not to develop an SOD severity index. For example, this may occur at unoccupied sites or sites with single unknown status. SOP 2: Standard Field Methods provides detailed instructions for developing the SOD severity index at each site.

The SOD severity rating will compliment other anticipated SOD data sources. For example, in 2010, PORE submitted a USDA grant proposal to quantify the potential impacts of SOD on northern spotted owls within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests. Forty-eight SOD sample plots established by Moritz et al. (2008) were re-visited by the authors in 2009 and would be re-visited again under the USDA grant. We expect to benefit from other SOD research efforts in California led by universities and county, state, and federal land management agencies.

### 3.5 End of Season Procedures

At the end of the season, monitoring equipment is cleaned and stored at both PORE and GOGA. At PORE, storage of monitoring supplies is in the basement of the Resource Management building, Science office, and Lead Biological Technician's office. At GOGA, equipment is stored in Fort Cronkhite Building 1061 (Resource Management Building, Wildlife Ecologist's office) and in Fort Cronkhite Building 1063 (SFAN I&M Building, SFAN Data Manager's office and Dry Lab).

Following data entry and proofing (described in Section 4.0 below, SOP 4: Data Management Handbook), program and park staff analyze the data and produce a brief annual monitoring report with basic data summaries and any natural history items of note using the NPS Natural Resource Technical Report template (see SOP 5: Data Analysis and Reporting). The report provides pertinent updates to the park program managers and I&M Program Manager for inclusion in other reporting requirements (e.g., Annual Administrative Report and Workplan or for website updates). The report is posted to the SFAN I&M website.

The number of volunteers and the total volunteer hours spent on the owl program is summed by program staff and provided to the I&M Program Manager and to volunteer coordinators at GOGA and PORE for use in annual volunteers in parks reporting.

All digital photographs taken during the field season should be labeled with site name and date and collected by the Data Manager or Lead Biological Technician and put on a cd-rom to include with the final report and copy of master and satellite databases. Publication quality photographs should be submitted to the I&M Program Manager for use with the annual reporting along with a caption or explanation of the photograph.

Following all error-checking and proofing, all site survey forms are printed, attached to the corresponding field map for each site visit, and placed in a binder for that year. Included in the binder are a hardcopy of the annual report, any larger maps that were printed, and a CD containing a copy of the complete satellite and NSOMASTERXP databases and an electronic copy of the annual report. Any paper datasheets completed in the field are cataloged in a separate binder. The binders are submitted to the PORE Curatorial Manager two years after the field season to allow for ease of access to field maps by subsequent field staff (e.g., the 2007 data are archived in 2009).

The California Department of Fish and Game maintains the central repository for California NSO location information in the Biogeographic Information and Observation System (BIOS) data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. The submission consists of a GIS shapefile with metadata of northern spotted owls activity centers monitored each year. The shapefile is an important annual product of the monitoring program, and a copy with associated metadata is saved to the PORE GIS server.  Additional end of season procedures are detailed SOP 2: Field Methods, SOP 4: Data Management Handbook and SOP 5: Data Analysis and Reporting.

# 4.0 Data Handling, Analysis, and Reporting

## 4.1 Overview of Database Design

The Marin County Spotted Owl Database, created in 2000, is currently in MS Access XP format (NSOMasterXP.mdb). The SFAN Data Manager currently manages the database. The database remains in its original format with periodic updates or minor changes, which are documented in a separate revision log.

A full description of the major database tables, database design, and a data management handbook is in SOP 4: Data Management Handbook. The SOP describes the design, tables, forms, and queries critical to the database operation. SOP 4 contains additional guidelines for data entry procedures, error-checking procedures, database versioning, and data archiving. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the SFAN monitoring program are detailed in the program's Data Management Plan (Press 2005). MS Access XP is the primary software environment for managing the NSO monitoring data. ESRI ArcGIS serves as a tool for validation of spatial data residing in MS Access and for plotting site locations on park maps.

The program database consists of a single master database that contains the tables, forms, queries, and reports. Satellite databases are created at the beginning of each season and contain the structure of the master database, but with the field data tables left unpopulated. Data related to the area surveyed, which can be an existing territory or potential habitat, are entered into the SEARCH table. Multiple survey events can be associated with one territory location. If owls are observed during the survey, details are recorded in the DETECTIONS table. Detections information collected includes UTM coordinates (via GPS if possible) for each owl species. Data are also recorded if no owls are observed so that negative survey results are tracked. If mice are used during the survey, details on how long each mouse is offered and disposition of mouse is recorded in the MICE table, which is linked to the SEARCH table. If the survey is for inventory purposes or in a new territory, call points are used during the survey. Information on the call points and their UTM coordinates are recorded in the CALLPOINTS and CALLPTSLOCAs tables. If a nest is observed at a territory, details on the nest location and nest habitat are collected near the end of the season and entered in the NESTTREES table. Additional tables include OWLBANDS which stores data on all the banded owls within the survey area (approximately 110); and the STATUS table which is a summary table created at the end of the season after reviewing all the detection information gathered at a territory.

## 4.2 Data Entry, Verification, and Editing

An electronic Site Search data form is required for all field visits and the electronic entry of the Nest Site Habitat data field form is required for each nest with a known location. The blank Site Search data forms can be printed directly from the project database and filled out in the field, but if a field notebook is used, the electronic data form should be entered in the database within a week of the visit.

Two people participate in the data verification with one person reading the original out loud to another person looking at the computer monitor to verify that the two records match. If only one person is available, he or she should have any field notes or data forms in front of him or her.

They should then correct any mistakes and check the "error-checked" box on the form. Per the SFAN Data Management Plan, several quality assurance/quality control (QA/QC) procedures must be followed by the database user: 1) Have a familiarity with the database software, database structure, and any standard codes for data entry that have been developed; 2) enter or download data in a timely manner; and, 3) enter the data, one logical "set" at a time (Press 2005).

Field data should be entered into the satellite databases, verified and submitted to the Lead Biological Technician by August 15 of each year. The Lead Biological Technician will review the individual databases for missing data and other obvious inconsistencies before compiling them into an annual database. The annual database will undergo the standardized database error-checking procedures as outlined in SOP 4: Data Management Handbook. Field maps shall also be completed by August 15 and submitted to the Lead Biological Technician (SOP 2: Standard Field Procedures).

### 4.3 Metadata Procedures

Formal metadata has been completed for the program database and is provided on the NPS Data Store website (http://science.nature.nps.gov/nrdata/index.cfm). Each table and field in the project database was defined and documented using the NPS Metadata Tools and Editor (MTE) and Dataset Catalog. The database, and any GIS data resulting from the monitoring program, is considered sensitive information and is not available publicly, but distributed through data requests to the Data Manager. Further details on metadata development and distribution are provided in SOP 4: Data Management Handbook.

The complete protocol for this project (Protocol Narrative and SOPs) is an integral component of the project metadata. All narrative and SOP version changes are noted in the Master Version Table (MVT), which is maintained in SOP 7: Revising the Protocol. Any time the narrative or SOP versions are changed, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be interpreted and analyzed properly. The protocol narrative, SOPs, and data should not be distributed independently of this table.

### 4.4 Annual Data Summaries

At the end of each season, following data entry and proofing, each field team works with the Lead Biological Technician to determine the final season status for each territory using survey results and protocols. At least two people should review the data for each territory to make sure that the survey results provide necessary documentation for occupancy and reproductive determinations based on SOP 3: Status Determinations.

All NSO monitoring data are entered into the database, including submissions from PRBO of other Marin County territories monitored for management purposes. For the annual reports, only NPS occupancy and fecundity data collected within the NSO study area are summarized and presented. The exception is the nesting habitat and nest structures section of the annual report, which includes data gathered on all nests located in the Marin County since 1998.

Site occupancy and reproductive status are reported directly as percentages of different occupancy and reproductive status classes. Annual population fecundity is determined by calculating an average fecundity of territorial females within the monitored sample. Fecundity is the number of female young (# of fledglings/2) per territorial female (Franklin et al. 1996). Standard error of the sample is also reported.

Other metrics included in the annual summary:

- Age composition of pairs
- Survey effort (mean and range of number of visits per site)
- Nest tree measurements (nest type, height, aspect, tree species, dbh)
- Habitat characteristics (dominant overstory, elevation, slope, distance to water, etc.)
- Breeding season weather metrics

Incidental data collected are also reported, including:

- Barred owl statistics (number of detections, number of NSO sites with barred owls detected)
- Medium to large scale changes in NSO habitat (e.g., wildfires)

Further details for the contents of the annual summary including sample tables and figures are provided in SOP 5: Data Analysis and Reporting.

### 4.5 Annual Reporting Schedule

An annual report is produced for the long-term monitoring sites and is prepared by the Lead Biological Technician in coordination with the project lead(s). The report is reviewed by the project staff from PORE and GOGA. The first draft of the report is produced in the late-summer or fall following the field season once the data has all been error-checked. Peer-review and completion of the report are the responsibilities of the NSO program managers and should be finalized before the start of the next field season.

The annual report summarizes the field and data collection activities from the season and includes the data summaries listed above in the context of data from previous years. The most recent 2008 Annual Report (Jensen et al. 2010) is available online at:

http://science.nature.nps.gov/im/units/sfan/vital_signs/Spotted_Owl/birds.cfm

The 2008 annual report, which went through a formal peer review process, will serve as a template for future annual reports. Report figures are formatted in a MS Excel spreadsheet and can be updated each year and inserted into the report. Additional details on reporting are in SOP 5: Data Analysis and Reporting.

### 4.6 Long-term Trend Analysis Reporting

Every 5 years, the program will undergo a larger trend analysis and protocol review. The focus of the trend assessments will be on the key parameters in the study design (territory occupancy rate and fecundity).

Occupancy and fecundity estimates will be obtained annually and will provide measures of status. When more than three years of monitoring data are available, linear trends in the logged odds of occupancy may be estimated and tested for significance. The number of detections is modeled as a zero-inflated binomial random variable (MacKenzie et al. 2006). To test for trends in occupancy and fecundity, the year covariate is included as a predictor in the occupancy and fecundity models and then tested for significance with likelihood ratio tests.

The methods for detecting long-term trends in the NSO occupancy and fecundity data were developed by Starcevich and Steinhorst (2010; Appendix A), which used 10 years of NPS NSO monitoring data to estimate the power to detect trends in preparation for this protocol (see Section 2.2 Sample Design Power Analysis). Methodology for trend analysis of occupancy and fecundity rates is provided in SOP 5: Data Analysis and Reporting, with pilot data provided in SOP 5 Appendix B. Instructions are given for the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

Additional factors will be analyzed in the trend reports such as differences in occupancy and fecundity rates between age classes of females and males, different nesting habitat factors, effects of climatic and weather conditions, and presence of barred owls. The analyses will also show the NPS NSO population within the context of Marin County, by including data collected on MMWD and MCOSD lands, and within a regional context, by comparing NSO trends in other parts of California.

Information about NSO habitat associations from this region could have important management and ecological implications and will therefore be explored by the SFAN monitoring program as a component of long-term trend analyses. SOP 5: Data Analysis and Reporting outlines our approach to analyzing nest site measurements collected in the field and developing NSO habitat models in GIS that incorporate both field measurements and landscape variables.

As described in SOP 5: Data Analysis and Reporting, data collected on barred owl presence and SOD severity at the NSO monitoring sites will be incorporated as important covariates in our long-term occupancy, fecundity, and habitat analyses. The significance of these effects may be assessed with likelihood ratio tests of regression coefficients in the models for occupancy, fecundity, or detection rates.

## 4.7 Report Formats

All documents produced by the NSO monitoring program will be published in either the Natural Resource Report Series or the Natural Resource Technical Report Series following guidance from the NPS Natural Resource Program Center in Fort Collins, CO. Published reports will adhere to a set of strict formatting standards and are peer-reviewed to ensure that information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. The Natural Resource Publications Management home page hosts a list of all documents published in the NRR and NRTR Series. The home page can be found at: http://www.nature.nps.gov/publications/NRPM/

### 4.8 Other Reporting Requirements

Information is reported through a variety of other means detailed in the SOP 5: Data Analysis and Reporting. These reports include annual updates for the SFAN Annual Administrative Report and Workplan, updated resource briefings, informal updates through the SFAN Natural Resources and Science Monthly Update, park presentations, and online updates to the public internet site.

### 4.9 Report and Data Dissemination

In order for the NSO monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the NSO monitoring documents and data will be the Internet. The NSO monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website: http://science.nature.nps.gov/im/units/sfan/

The annual reports generally do not contain sensitive owl information and, therefore, can be distributed to the public. Any maps created are done in large scale and without specific landscape details and no owl locations are mentioned by name in the report.

Although the NSO monitoring database will not be posted for public download, metadata records for the master database will be maintained at the NPS Data Store. The metadata records will direct interested parties to the SFAN Data Manager for further inquiries.

In addition to the NPS Data Store of the NPS I&M Program maintains an on-line natural resource bibliographic database known as NatureBib. NatureBib records will be created for all of the NSO monitoring documents, including the protocol, annual reports, and any resulting publications.

The California Department of Fish and Game maintains BIOS data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program (see SOP 5: Data Analysis and Reporting). BIOS is the preferred central contact for dissemination of NSO data to appropriate parties.

### 4.10 Data and Report Archival Procedures

Annually following data proofing and error checking, the project database located on the PORE network (inppore04\Resources\Natural_Databases\Spotted Owl\NSOMasterXP.mdb) is archived onto a CD-ROM with a copy of the annual report and project protocols. All database related files reside on a secure server at PORE with regular backup routines and off-site storage rotation. All GIS related files reside at PORE (inppore07\GIS\vector\Wildlife\Spotted Owl). A mirror copy of the PORE spotted owl folder sits on the Network Drive (inpgogamahe1\Divisions\Network I&M\Individual Vital Signs\SpottedOwl) maintained by GOGA.

# 5.0 Personnel Requirements and Training

## 5.1 Roles and Responsibilities

The GOGA Wildlife Ecologist, the SFAN Data Manager, and the Lead Biological Technician are the program managers for the long-term monitoring program. Additional assistance for planning and coordination comes from an additional biological technician, the SFAN I&M Program Manager, PORE Science Advisor, PORE Chief of Resource Management, and GOGA Chief of Resource Management. PRBO works under contracts with the MMWD and MCOSD for monitoring and inventorying NSO on their lands and submits data to the NPS NSO database.

In general, the GOGA Wildlife Ecologist and SFAN Data Manager are responsible for managing the project database, training, and supervising the Lead Biological Technician (GS-07, term, subject to furlough position). The Lead Biological Technician is responsible for monitoring selected NSO sites, supervising the Biological Technician, providing field training to interns, communicating with the other field staff, providing project updates during the course of the season, consulting with field staff on protocol and database questions, data entry and error-checking, and writing the annual report. The Biological Technician (GS-05, term, subject to furlough position) is responsible for field monitoring at selected sites, data entry, error-checking the data, and other data management tasks. The GOGA Wildlife Ecologist and SFAN Data Manager assist with the monitoring of selected sites as needed. The Project Lead duties are currently assigned to the SFAN Data Manager (as of 5/12/08).

Tasks for Project Lead:

- Supervise the biological technicians
- Develop and conduct performance review (to be reviewed by I&M Program Manager)
- Manage owl monitoring program budget
- Provide or coordinate training for the biological technicians
- Conduct annual QA/QC field checks
- Present issues for consultation with the Technical Steering Committee
- Review and provide comments on annual report
- Initiate and complete long-term analysis and synthesis report
- Update protocol as needed
- Provide field assistance as needed to ensure coverage

Tasks for the Lead Biological Technician (GS-07):

- Coordinate logistics for field work
- Coordinate field assistance for protocol implementation and provide training to field assistants such as interns
- Maintain equipment in good working order and keep maintenance records
- Collect field data and implement field QA/QC measures
- Coordinate data entry, verification, and validation in consultation with SFAN Data Manager
- Perform summary statistical analyses on data; present and interpret results in annual reports
- Communicate results through a variety of media and channels including Annual Administrative Report and Workplan, executive briefing, I&M Update, and online websites

- Coordinate with Project Lead regarding staff and training needs, budget and equipment needs, vehicle, data analysis and data interpretation
- Production of annual hard copy binders

<u>Tasks for the Biological Technician (GS-05):</u>
- Provide training to field assistants such as interns
- Maintain equipment in good working order and keep maintenance records
- Collect field data and implement field QA/QC measures
- Perform data entry, verification, and validation in consultation with SFAN Data Manager
- Production of annual hard copy binders

<u>Tasks for the Project Intern or Volunteer:</u>
- Assist biological technicians with field work, data entry, and reporting

<u>Tasks for SFAN Data Manager:</u>
- Provide assistance to the biological technicians regarding data management, archiving, reporting
- Assist with GIS needs
- Assist with compilation of metadata for past and current monitoring programs
- Review protocol, annual reports, long-term trend analyses
- Assist with field work at selected monitoring sites

<u>Tasks for the GOGA Wildlife Ecologist and PORE Science Advisor:</u>
- Be well-versed in all aspects of the NSO Monitoring Protocol
- Provide technical assistance to the biological technicians
- Review protocol, annual reports, long-term trend analyses
- Assist with field work at selected monitoring sites

<u>Broad tasks for I&M Program Manager:</u>
- Broad programmatic oversight and review
- Coordinate guidance on data management, data analysis and reporting
- Provide information related to I&M program requirements, including reporting requirements and deadlines
- Review protocol, annual reports, long-term trend analyses
- Plan program budget in coordination with Project Lead
- Coordinate peer review of analysis and synthesis reports

## 5.2 Qualifications

Field personnel are required to have normal hearing abilities and either one season of experience doing NSO surveys, including field data collection, or training in NSO survey techniques. In addition, personnel must also be skilled with the use of GPS equipment for navigation and data collection. Observers should be well-organized, be able to make decisions in the field (based on a monitoring protocol), and work methodically under sometimes difficult conditions.

Because of the amount of training involved in attaining adequate experience required for consistent and accurate field data collection, the project employs few volunteers. Volunteers work under the supervision of project staff at all NPS sites.

### 5.3 Training Procedures

Training procedures are outlined in the attached SOP 1: Preparations and Equipment Setup Procedures and SOP 2: Standard Field Procedures. New and returning personnel are required to read this protocol and all SOPs, and the USFWS Protocol (1992) prior to field data collection.

In particular, all field personnel need to be familiar with:

- band colors and tabs (SOP 2),
- owl aging techniques (SOP 2 and 3),
- spotted, barred and hybrid owl plumage and calls (SOP 2),
- field safety considerations (SOP 6), and
- use of mice and mice management (SOP 2 and 3).

New full-time personnel are accompanied by returning field staff for on-the-job training typically until June. New part-time personnel and volunteers are paired with another more experienced field staff member throughout the season.

# 6.0 Operational Requirements

## 6.1 Annual Workload and Field Schedule

Field work is accomplished by two biological technicians with the support of interns and volunteers, from March 1 until approximately July 31. The SFAN Data Manager and the GOGA Wildlife Ecologist may take the lead on monitoring a few sites each year if needed. Monitoring may require 4-6 visits per territory in a season (up to four hours per visit). Surveys can be accomplished by a single observer, although two observers are recommended for efficiency and safety.

Immediately following the field season, the biological technicians will proof and error-check the database, produce the annual report and maps, and report results to federal, state and county agencies. General monitoring program tasks are listed with the target due date and lead person in Table 3.

Procedures for making changes to and archiving previous versions of the protocol and SOPs are described in SOP 7: Revising the Protocol. All personnel should be familiar with the revision requirements and naming schemes.

**Table 3.** Annual NSO program tasks.

| Activity | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Advertise technician vacancy (as needed) | | | | | | | | | | | | |
| Technician season | | | | | | | | | | | | |
| Field training (as needed) | | Late Feb | Early Mar | | | | | | | | | |
| Satellite copies of database to field crews | | | Mar 1 | | | | | | | | | |
| Field surveys and nest habitat sampling | | | | | | | | | | | | |
| Satellite database data entry | | | | | | | Due July 31 | | | | | |
| Data error-checking, merge with master database. | | | | | | | | Aug 15 | | | | |
| Site summaries, GIS layer production | | | | | | | | Aug 31 | | | | |
| Data hardcopy binders | | | | | | | | | Sept 30 | | | |
| BIOS annual reporting | | | | | | | | | Sept 30 | | | |
| Annual report production (draft) | | | | | | | | | Sept 30 | | | |

## 6.2 Facility and Equipment Needs

Office space with computers for the biological technicians along with equipment storage space and a place to house live mice is provided by PORE. SOP 1: Preparations and Equipment Setup Procedures, lists field equipment needs for each field team.

## 6.3 Budget

Estimated costs for conducting NSO monitoring are shown in Table 4. The budget is based on FY10 cost estimates with costs expected to increase annually by approximately 4%. Personnel expenses for fieldwork are based on the biological technicians doing the majority of the fieldwork with assistance from permanent the GOGA Wildlife Ecologist, SFAN Data Manager, interns, and volunteers. The Lead Biological Technician is also responsible for preparing the annual monitoring report. The initial annual budget for the project is estimated to be $83,850, which includes salaries of permanent NPS staff supporting the project. The estimate does not include in-kind services of volunteers. Field costs may vary from year to year depending on the skill level and experience of the biological technicians.

**Table 4.** Estimated annual SFAN NSO monitoring program budget based on FY10 cost estimates.

| | Description | Cost |
|---|---|---|
| **Funding Source** | Park contribution (PORE) | -0- |
| | Park contribution (GOGA) | $4,500 |
| | SFAN I&M contribution | $79,350 |
| | Sub-total | $83,850 |
| **Expense Type** | Biological Tech GS-7 – 16 pp | $47,000 |
| | Biological Tech GS-5 – 14 pp | $24,000 |
| | SFAN Data Manager GS-11 – 1pp | $3,900 |
| | Wildlife Ecologist – GOGA GS-12 – 1pp | $4,500 |
| | Vehicle | $3,000 |
| | Equipment and supplies | $750 |
| | Travel, training, meetings | $700 |
| | Sub-total | $83,850 |
| | Balance | -0- |

Additional periodic costs may be incurred if new equipment (e.g., spotting scopes and binoculars) are needed beyond those allowable by the annual budget. If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports.

## 6.4 Permit Requirements

Neither an Endangered Species Act Recovery Permit nor a USGS banding permit is required for calling or monitoring NSO surveys. Using a caller to attract wildlife is prohibited within the NPS lands though, and does require permission from the Superintendent and/or an NPS research and collecting permit. This permit will be obtained through the NPS Research Permit and Reporting System: https://science1.nature.nps.gov/research/ac/ResearchIndex.

# 7.0 Glossary

Abundance – In this context, abundance refers to the mean number of adult NSOs at the activity centers monitored or mean number of NSOs located during an inventory effort.

Activity center – Interchangeable term with ‘known and/or historic site center’. This area represents the area surrounding concentrations of ‘the best of’ detections such as nest stands, stands used by roosting pairs or territorial singles, or areas of concentrated nighttime detections.

Adult: A northern spotted owl ≥ 2 years old.

Breeding season – The time period that includes pair initiation, nesting, and fledging of young. The window is considered to be March 1 to September 1 for the purposes of conducting surveys to detect NSO (USFWS 1992; Forsman 1995); and considered to be February 1 to July 31 by USFWS for the purposes of limiting management activities that may affect nesting NSO.

Breeding years – Typical years when spotted owls breed during the nesting season; see also non-breeding years.

Fecundity – A measure of reproductive success typically reported as the number of female young fledged per territorial female (e.g., Anthony et al. 2006)

Home range – The area annually traversed by spotted owls that provide important habitat elements for breeding, feeding, and sheltering

Inventory – A large scale survey of suitable NSO habitat to detect the number and occupancy status of activity centers within a designated area.

Mousing – Mousing describes the act of offering prey items to spotted owls. The purpose of mousing spotted owls is to determine pair status and/or reproductive status. A male spotted owl may take a prey item to an unseen female, likewise, adult owls may take prey items to unseen young.

Nest – Northern spotted owls use broken-topped trees, old raptor nests, witches broom, cliff ledges, mistletoe brooms, and tree cavities for nests. A spotted owl must be observed using the structure or have mice taken to a nesting female positively identified in the structure to designate a nest tree.

Nestling – A young owl that is still in the nest.

Non-breeding years – Non-breeding years refers to breeding seasons when NSOs did not breed across a large landscape. This occurrence was documented in Marin County in 2007 when there were no breeding pairs on federal lands.

NSO – Northern spotted owl.

Occupancy – Determination that an area or activity center contains an owl or owls. A survey area can be considered "occupied" if at any time throughout the year a NSO is detected. Assigning a level of occupancy, nesting, or reproductive status must occur within the breeding season.

Productivity – A measure of reproductive success reported as the number of young fledged per territorial pair (e.g., Anthony et al. 2006).

Reproductive status – Determination that nesting owls have laid eggs or have nestlings/ fledglings.

Reproductive success – Measures used to describe the amount of reproduction that occurred annually. See fecundity and productivity.

Roost – Typically a tree used by a spotted owl for extended daytime rest periods. A roost site consists of the roost itself and the immediate vicinity. Roost areas are identified by observations of spotted owls, and/or the presence of pellets, whitewash and other evidence.

Spotted Owl Site - See Territory.

Subadult – A spotted owl in the first or second years of life.

Territory – Area defended and used by a territorial NSO single or pair for foraging, roosting, and nesting; often referred to as a NSO "site" and includes an activity center.

Vital Signs – As used by the National Park Service, are the subset of indicators chosen a by park or park network as part of the vital signs monitoring program. They are defined as any measurable feature of the environment that provides insights into changes in the state of the ecosystem. Vital signs are intended to track changes in a subset of park resources and processes that are determined to be the most significant indicators of ecological condition of those specific resources that are of the greatest concern to each park. This subset of resources and processes is part of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on these resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic levels, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

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# SOP 1. Preparations and Equipment Setup Procedures
*Version 1.3*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| 1.0 | 12/8/07 | D. Adams | Format, slight content revisions | Respond to reviewer comments. | 1.1 |
| 1.1 | 05/18/08 | D. Adams, Paul Johnson, Marcus Koenen | Minor content revision to equip list and volunteer mgmt | Incorporate staff edits | 1.2 |
| 1.2 | 03/04/10 | D. Press | Minor content revision. Added more detail on volunteers. Added section on training new staff. | In response to peer review comments. | 1.3 |

## Contents

This SOP outlines the basic activities carried out at the onset of each field season (March).

# 1.0 Prepare Field Maps

Each field team should have field maps for each site for navigation to the designated activity sites and for preparing site search maps for each visit. Maps for each of the monitoring sites are created using GIS and facilitate finding past Northern Spotted Owl (NSO) nests and activity centers in the field. Use topographic maps as a base layer with the addition of labeled roads, trails and past NSO nest site occurrences. Create the 8-1/2x11 field map using no greater than a 1:18,000 scale, include a scale bar, north arrow and title with the minimum of the area identified.

# 2.0 Pre-season Meeting

Project leader or Lead Biological Technician schedules a pre-season meeting in February or early March to bring together all the project personnel and plan for the year's activities. Identify roles and responsibilities during the meeting if they are unclear or new personnel will be participating.

1. Assign NSO survey sites to field personnel including biological technicians, intern, GOGA Wildlife Ecologist, SFAN Data Manager, volunteers, or other staff.

2. Provide annual satellite databases for all field crews.

3. Review Training Topics:
    - Protocols and SOPs
    - Band colors and tabs
    - NSO aging techniques
    - Spotted, barred and hybrid owl plumage and calls
    - Field safety considerations (See SOP 6: Safety Procedures)
    - Mice maintenance

4. Review Equipment Needs

Review the condition and location of equipment needed for the season. Generally, four-wheel drive government vehicles are used for accessing NSO owl sites via park roads and trails. Where and when possible though, biologists should hike and use mountain bikes on park trails.

Monitoring equipment is stored at both PORE and GOGA. At PORE, storage of monitoring supplies is in the basement of the Resource Management building, Science office, and Lead Biological Technician's office. At GOGA, equipment is stored in Fort Cronkhite Building 1061 (Resource Management Building, Wildlife Ecologist's office) and in Fort Cronkhite Building 1063 (SFAN I&M Building, SFAN Data Manager's office and Dry Lab).

Domestic or pet mice used for baiting NSOs are typically purchased at area pet stores and one person from the field team is responsible for feeding and caring for them. Generally, 8-20 mice are needed on hand depending on the time period in the season. Small cages are used to carry the mice (4-6 at a time) into the field.

Each field team needs:

- Megaphone, tape player, owl tape, and/or hoot flute
- Batteries (AA, C, and D for megaphones)
- Spotting scope and tripod
- Datasheets (site search and nest forms)
- Watch
- Thermometer
- Specimen collecting envelopes and bags
- Field clothing
- Mouse lure and mice, if necessary
- Aluminum tree tags and nails
- Flagging
- Park radio and/or cell phone
- Binoculars
- Field notebook
- Compass
- Field maps
- GPS unit
- Headlamps/flashlights
- Extra water and food.
- Banding list
- Monitoring protocol

# 3.0 Volunteer and Intern Management

During the pre-season meeting it is important to identify which long-term and new volunteers or interns will participate in the NSO monitoring field work, the range of work they are authorized to do (e.g., visit sites independently and collect data or only accompany a trained field crew member). SFAN staff must determine who will be scheduling their work and supervising their activities. Volunteers may assist long-term monitoring efforts covered by this protocol when accompanying other assigned field staff. At the SFAN staff's discretion, volunteers may be permitted to conduct surveys on their own. This has been particularly helpful in the past with simple nest checks. Volunteers will not be permitted to work independently until their abilities to follow proper procedures and accurately record data consistent with the monitoring protocol are confirmed by SFAN staff. Volunteer supervisors should track each volunteer's hours and provide them to the Lead Biological Technician for the annual report and to the individual park Volunteers in Parks Coordinators.

# 4.0 Training New Staff

New field observers hired by the SFAN for the NSO monitoring program will require significant training by existing staff. If possible, the SFAN should try to hire biologists with previous experience monitoring northern spotted owls. New hires will be required to become intimately familiar with field procedures and must accompany existing staff into the field on numerous surveys in order to orient themselves to the monitoring sites and learn field techniques first hand. New staff will not be permitted to work independently until their abilities to follow proper procedures and accurately record data consistent with the monitoring protocol are confirmed by SFAN staff.

# SOP 2. Standard Field Procedures

*Version 1.4*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| 1.1 | 12/8/07 | D. Adams | Format, slight content revisions | Respond to reviewer comments. | 1.2 |
| 1.2 | 02/19/08 | D. Adams | Content corrections | Response to internal review comments | 1.3 |
| 1.3 | 04/19/10 | D. Press | Re-organization of figures. Format edits. Added SOD severity methods. Mention of USFWS 2010 protocol. Added Literature Cited section. | To meet current formatting guidance and respond to peer review comments. | 1.4 |

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This standard operating procedure (SOP) outlines basic field survey procedures and guidelines, data collection, and documentation for the SFAN Northern Spotted Owl (NSO) monitoring program. The sections on survey methods, data collection and documentation, and specific field procedures were adapted from other existing monitoring protocols including those by Forsman (1995), the USFWS (1992), and Fehring et al. (2001).

Research on spotted owls over the last decade has raised concerns regarding the effectiveness of the USFWS 1992 survey protocol, particularly those which do not result in spotted owl detections, most likely due to barred owl presence. An interagency Barred Owl Work Group and its Survey Protocol Subcommitte, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

# 1.0 Survey Period

Informal surveys or incidental detections may occur any time during the year, but data involving occupancy and reproductive status designation as well as valid band confirmations must occur within specified time periods as described in this SOP. In general, surveys to establish the presence of territorial pairs or singles and to establish reproductive status will take place between March 1 and July 31 for the purposes of this monitoring protocol. All designated monitoring sites in Marin County should be surveyed at least once by April 15 to determine occupancy. In addition, the sites should be visited between April 15 and May 1 to determine nesting status.

# 2.0 Survey Area

The first survey of the season at each site should be an abbreviated search of the most recent activity center. The first day search can be expanded to include known roost areas and historic nest cores, especially if evidence of whitewash or pellets is found and/or there is easy access to past activity centers. If the first day visit is conducted in April, a more extensive search of past activity centers is justified. The shortened survey effort is due to the fact that owls at reliable territories (e.g., those with solid occupancy histories) will often appear in the historic core area in April.

If owls are not detected on the first visit, the second visit will entail an extensive search of all historic activity areas. Depending on evidence found and site history, the second visit could be a night survey. For example, if no evidence of owl presence was located on the first visit and the history of owl occupancy is unknown, a night survey is probably the best option for the second visit. If no response is heard on a second day visit, switch to night surveys to locate owls. It is a good idea to be ready to call at the activity site core at dusk when completing a night survey. This increases the chances of locating the area where the owls are roosting during the day before they start moving throughout the territory at night. If night access is limited to one effective call point to cover the area, complete a 30+ minute call station from that location. Follow-ups to night surveys with NSO detections should be substantial; plan on spending several hours searching the area where the owl was heard.

# 3.0 Survey Methods

## 3.1 Scheduling Field Surveys

All sites that will be surveyed to determine occupancy status may take a minimum of one (if a pair is detected) and up to five visits to maximize detectability based on previous monitoring data (Connor and Lebuhn 2007c). Band identification, age, sex, and species verification should be determined for all NSO detected. Sites that are monitored for reproductive status will likely need additional visits after occupancy status is determined to locate the nest and confirm the number of young produced and fledged.

Do not survey under inclement weather conditions, such as high winds (>10 mph), rain, or high noise levels (stream noise, machinery, etc.) that would prevent you from hearing a response that would be heard under better conditions.

## 3.2 Sites with Recent Spotted Owl History

Initial attempts to determine occupancy status at sites with reliable histories within the previous two years should be conducted during daylight for the first two visits. If no owls or a single owl is detected during the initial day visits, subsequent surveys should occur during dusk, night, or predawn hours to determine pair status. If necessary, at least one night visit should occur before the end of April and an attempt should be made to complete two night visits before June 1. Sites with recent history, but no detections for the season should receive three night visits.

## 3.3 Sites with Inconsistent or No Recent Spotted Owl History

Sites with no recent owl history should be visited three times at night if no response is detected. Two of the night visits should occur before the end of June. An historic site will be considered unoccupied if it receives three night visits with no response. If owl response is heard during a night survey, follow-ups need to be conducted the next day except in the case of extreme circumstances or inclement weather. If a response is detected numerous times on night surveys, but owls cannot be located during day survey efforts, switch efforts to pre-dawn surveys so that a search can be conducted as soon there is sufficient light to safely enter forest.

Early season work is important because locating a nest or definitively determining non-nesting may reduce the need for further site visits.

## 3.4 Day Surveys

1) Day surveys should be the first visit for all sites with a well-established activity center. They are also used to follow up on any night survey response. The additional search effort can minimize the amount of calling required to locate owls in the daytime.

    a) Conduct a search of the known nest/roost area for at least 30 minutes, documenting all owls seen or heard as well as whitewash, pellets or other evidence.

b) If no owls are located, initiate calling and continue an expanded search for at least an additional hour and covering up to ½ mile radius around the historic activity center. Focus expanded searches around any observed evidence. If no evidence is found, conduct a night survey covering the potential habitat.

**2)** If owls are located, record the species, sex, age, and band color as well as completing all of the fields in the datasheet. Indicate the methods used to determine species, sex and age in the narrative (4-note calls, appearance of tail tips, color bands, behaviors etc.)

### 3.5 Night Surveys

The intent is to obtain complete coverage of the area of interest such that owls will be able to hear the surveyor and the surveyor will be able to hear the owls.

1) Establish calling stations and survey routes to achieve complete coverage of the area. Calling stations should be spaced 400 to 800 m (0.25 to 0.5 mile) apart, depending on topography. Take advantage of prominent points within the calling area when establishing calling stations.

2) Conduct night surveys between sunset and sunrise. Be sure not to call the same section of a survey route at the same time on each survey effort (i.e., vary the time that you start and the point from which you start your route).

3) Systematically survey the area of interest until an owl responds, or if no response, until a minimum of three complete night visits are conducted each year. Survey effort should be spread out over two to three months to avoid survey efforts concentrated in a short period of time (e.g., in a three-week period at the start of the survey season).

4) Follow the survey methods listed below (spot calling is the recommended method). Whatever method you use, be sure you cover all potential areas within the historic activity site area.

    a) **Spot calling:** Set up a series of calling stations approximately 400 m (0.25 mile) apart along a road. When possible, pick prominent points that cover large areas. Spend at least 10 minutes at each station, more if the topography prevents you from hearing owls that might respond from the previous calling point (e.g., you cross a major ridge). If the topography lends itself to fewer, prominent calling points, spend more time at each station. If a response is elicited, stop calling immediately and listen carefully to identify the owl's species, gender and location. A complete 10 minutes of calling is not required if a response has been elicited.

    b) **Continuous walking or leapfrog surveys:** Walk the designated route, stopping at frequent intervals to call and listen for responses. If two people are involved, you may use a leapfrog method (see Forsman 1983).

5) If owls are heard during a survey:

a) Estimate the original and final location of the owl(s). The best method is to triangulate on the owl's calls, taking compass bearings from two to three locations. Be sure to record on the survey form the method used to estimate the location.

b) Record the location on a map attached to the survey form. The triangulation and accompanying map provide a means for verification of the location.

6) If an owl responds at any station, record the data as required. If no response is heard, proceed to the next station calling point. Continue until the defined area is completely covered.

7) If an owl responds at night, return to the area during the day as soon as possible (see Day Surveys) to verify status as described below.

8) If a response occurs during dusk or pre-dawn hours and there is sufficient time and light to complete status verification, do so.

9) If the survey is for inventory purposes, once a owl responds at night, complete the survey route for the remaining stations points that are beyond earshot of the responding owl. Beyond earshot is generally over a ridge or at least 800 m to 1200 m (0.5 to 0.75 mile) away. Completing the route will provide an opportunity to detect any other owls in the area.

# 4.0 Data Collection and Documentation

In order to establish consistency among the various Marin County survey units, a minimum set of information is required to be collected. Whether or not owls are located, a Site Search Form form (Figure SOP 2.1) is required for all field visits. All fields on the Site Search Form should be filled out and a written narrative completed documenting all relevant events. For all field visits you should record the site name, weather, start and end time, a description of the area covered, the purpose of survey (e.g., “Purpose of visit is to locate male and determine his band and age” or “Purpose of visit is to confirm reproductive success with second fledgling count”) and results of visit (see detailed Site Search Form section below).

Be aware of the current status of the site you are visiting and know what data are needed. Since we don’t regularly use “mousing” to determine status it is of the utmost importance to record detailed and accurate field notes. Take notes in chronological order using specific times to indicate notable events. For all daytime observation you should note the time you get both an audio and any visual responses from an owl.

Note how you knew it was a NSO versus a barred owl. Note where you located the owl(s). Indicate the sex and types of NSO responses observed. Note the age of the owls and how it was determined. Always note band and tab color and leg, determination of no band if you can determine it, or if leg observation is not possible that the band is unknown (see Reading Color Bands section below). Always make an effort to determine this information. Never record age, sex, and band determination in the detection table if you did not observe it and are not 100% positive of your determination. Describe the behavior of the owls. During non-nesting visits make sure to note the length of time that a female is observed roosting in view.

## Northern Spotted Owl Site Search Form

Crew:

Form I.D.#: Site Name: Owl Site #: Date:

Recorder: Lead Observer: Other Observers' Initials: #Observers:

### Visit Times

Visit Start Time:

Call Start Time : Call Method: (V,T,B,N) Visit End Time:

### Conditions Summary

Wind: Precipitation: Temp. (F.): Clouds%: Light:

### Visit Summary

Formal Survey? Purpose of Visit: SPOW Response?

Other Raptor or Corvid Species Detected:

Were mice offered?

Mousing Purpose:

Total #Mice Taken:

Mice taken to nest?

Was an effort made to see bands?

View into the nest was adequate to see all owls that might be in it?

Total # SPOW Detected On This Visit Of:

Mature owls:

Nestlings:

Branchers:

Fledglings:

### Owl and Other Raptor Detections

| species | sex | tail | age | time | A/V | band color | tab | leg | UTM-E | UTM-N | meth | acc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |

### Mousing Effort

| mouse# | time out | time taken | fate | fate time | sex | age | notes |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**Evidence**

check up to 6

- ☐ None
- ☐ Pellets
- ☐ Feathers
- ☐ Whitewash
- ☐ Dead Owl
- ☐ Eggshell(s)

**Non-Nesting Indicators**

check the most significant

- ☐ 0=None
- ☐ 1=No Brood Patch on Female 4/15 thru 6/15
- ☐ 2=Female Roosting 60+min. 4/15 thru 4/30
- ☐ 3=Prey taken, but not to nest 4/1 thru 6/15

**Nesting Indicators**

check the most significant

- ☐ 0=None
- ☐ 1=Nestlings Seen
- ☐ 2=Female on Nest
- ☐ 3=Prey Taken to Nest
- ☐ 4=Brood Patch on Female
- ☐ 5=Regenerating Brood Patch

**Reproduction**

check what is known about this site

- ☐ 1=Unknown
- ☐ 2=Non-Reproducing
- ☐ 3=Confirmed Nest Failure
- ☐ 4=Reproduced

NARRATIVE (Record all information that justifies your data sheet and describe details.)

**Figure SOP 2.1.** Site Search Form used for monitoring spotted owls in the San Francisco Bay Area Network.

For multiple or moving owls, record and number each response or observation. Make note of types of vocalizations heard, movements of owls (toward or away from you), or situations such as when one response is received and the owl is quiet thereafter. This will give the person(s) analyzing the data and determining activity centers additional information to consider. Be especially cognizant of the possibility that you may hear hybrid owls, and make careful notes of unusual vocalizations.

When owls are detected on a night survey, you should note the species, response time, compass bearing, approximate distance, and a description of calls. For all spotted owl responses also note the sex and any movement the owl makes. Use triangulation to pinpoint location of night auditory detections.

If nesting is detected, be sure to record detailed notes regarding the location of nest tree and nesting structure so that return visits can be made to collect nest habitat measurements. Record any visual cues that may aid in identifying the tree on a subsequent visit. Make an effort to obtain a GPS location. Record enough detail so that someone else can easily locate the nest tree if needed.

The Site Search Forms can be printed directly from the project database. Ideally, data forms are filled out in the field, but if a field notebook is used instead, forms should be filled out as soon as possible upon returning to the office. As a general rule, data forms should be completed and entered into the database within a week of the visit. This way the information is still fresh in your mind and you may be to provide additional details to your notes, but most importantly it is insurance that if you lose the datasheet or field notebook the visit is documented elsewhere.

### 4.1 Field Survey Map

A field survey map is required for all field visits other than nest checks (because the location is known from a previous map). The field survey map templates should be created for each area or site at the beginning of the season by each field team. Previous years' maps are acceptable as long as the documentation on the map is clear.

Noted on the field survey map should be the owl site, date, time period of visit using military time (e.g., 1300 – 1550), form id number for database form, outcome of visit (e.g., nest/FA/MA), location of nest and owls detected including sex, age, and bands, any call points used, and area searched. For both day and night surveys, field maps should also represent route surveyed and stations called and should correspond to the narrative text in the Site Search Form.

All spotted, barred, great horned, barn, saw-whet, pygmy, screech owl and accipiter response or observation locations should be noted on the field survey map and Site Search Form. For multiple or moving owls, map all response or observation locations and number each location to correspond with survey results and narrative.

## 5.0 Specific Field Procedures

### 5.1 Ageing Owls

Always make an attempt to look at an owl's tail tips on every survey. If it is perched high or obscured by foliage, a lure (rat toy) can be used to entice an owl to move to allow a visual of its legs for bands and tail tips. An owl cannot be recorded as an adult unless the tail tips are seen, because there is no plumage difference between an adult and subadult except for the tail tips. Adults have mottled and rounded tail tips. First year subadults (S1) and juveniles have white pointed tail tips. Second year subadults (S2) have white rounded tail tips. In the situation when the tail is clearly not an adult tail, but the surveyor is unable to differentiate further, the code (SA) is used to indicate a subadult, age unknown. It can be very difficult to determine between an S1 and S2, but it is especially difficult if the tail tips are wet or if there is a mix between white and plump rectrices and white and pointy rectrices, or if you have limited experience aging subadults. As long as a surveyor can determine an owl is a subadult (SA) and not an adult, it is not necessary to differentiate between S1 and S2. Molting of the rectrices can also occur during the breeding season, which can leave the owls temporarily tailless or with a mix of shorter and longer tail feathers or a mix of a subadult/adult tail tips or S1/S2 tail tips. Describe any odd tail observations in the comments section of the data form. If the surveyor is unable to achieve a good view of the tail tips, the age should be recorded as unknown. NSO and barred owls have similar terminal tail band patterns and the same characteristics can be used to age barred owls.

### 5.2 Identifying Calls

All surveyors should be very familiar with the range of calls that could be heard in the field from NSO, barred owls, great horned owls, western screech owls, saw-whet owls and other area raptors and corvids. As part of the early season training, each surveyor will receive an audio recording of owl calls to review.

### 5.3 Reading Color Bands

Always carry the list of banded owls in the field. Always note band color and leg or determination of no band if you can determine it. Always make an effort to determine this information. Do not assume that you will have another opportunity to see the owl. Never record age, sex, and band determination in the detection table if you did not observe it and are not 100% positive of your determination. For example, if you saw a flash of orange on the right leg, record band color as “present” in the detection table and explain what you saw in the comments field. If you saw only one leg and it was unbanded, include the information in the comments field, but select band color as “unknown”. Make sure you have a view of both legs, before determining a owl as unbanded and using the “none” category in the band color field. If you confirm a banded owl that is not a historic owl to that site refer to the banding list to identify where it originated and document this in the comment field of the Site Search Form and also in the final status summary. Make an extra effort to confirm bands on owls during the early season, particularly females. Females can prove to be more challenging to confirm and can elude confirmation even when nesting. If a nest fails or when a pair is non-nesting, the pair may not spend much time in the core area as the season progresses.

### 5.4 Collecting Feathers

If a surveyor locates a NSO feather during a survey, it should be collected and placed in a resealable bag, for potential future use in a genetic study. On the outside of the bag record the species, site name, date, collector’s name, UTMs of the feather’s location, and sex, age, and band ID of the owl the feather came from, if known. Record sex and age as unknown unless the surveyor actually witnesses the feather fall off of the owl or it is collected from the remains of a fledgling or nestling (in this case only the sex would be unknown). If you are unsure of the owl species from which the feather came from, collect it and the corresponding collection information and show it to the Lead Biological Technician for determination. At the end of the season, turn in all feathers to the Project Lead for storage.

## 5.5 Using a Compass

### *5.5.1 Compass Basics*

The magnetic declination for Point Reyes Station is 14° 52' E and changes by 0° 6' W/year. All compasses used in the owl monitoring program should have the ability to preset declination and should be set to this value.

### *5.5.2 Compass Components*

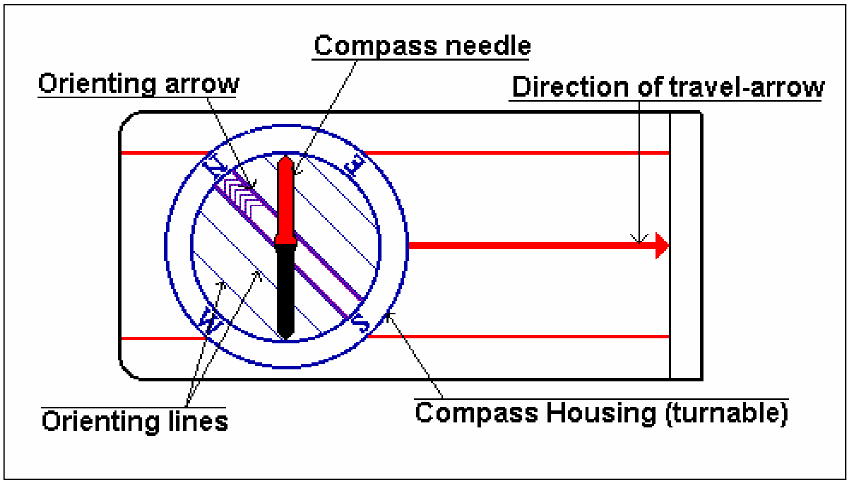



**Figure SOP 2.2.** Compass components.

### *5.5.3 How to Use a Compass*

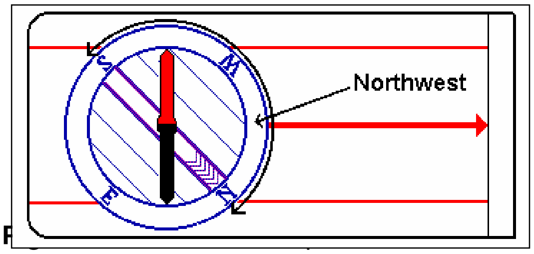
“Dial it up.” Use the compass housing to dial up a given compass bearing. In this case use 315 degrees (NW). See Figures SOP 2.2 and 2.3.

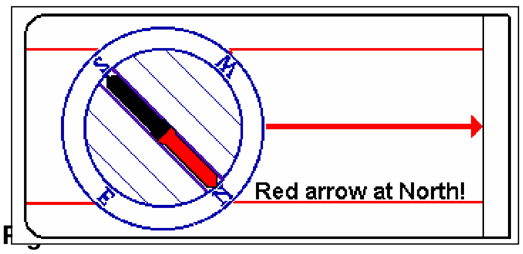
1. “Plug it in.” Act like you are plugging the compass into your body so that your shoulders and entire body turns with the compass and not just your arms. This will ensure you and the compass are pointed in the right direction.

“Put the red in the shed” by turning until the compass needle (the red) is in the orienting arrow (the shed). See Figure SOP 2.4.

Once you have the “red in the shed” look in front of you and find a landmark (tree, rock, etc.) the direction of travel arrow is pointing you.

2. Walk to the landmark and put the “red in the shed” again. Locate your next landmark and walk to it. Keep repeating this process until you reach your destination.




### *5.5.4 How to Triangulate on a Location*

Triangulation is used for identifying the point where two bearings intersect. We use triangulation to locate owls at night so that we can follow-up on that location the next day. In Figure SOP 2.5, “C” would be the owl’s location and “A” and “B” would be calling or listening stations.

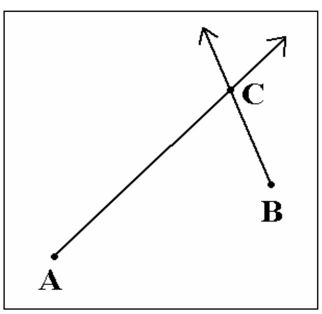



**Figure SOP 2.5.** Triangulation.

The same steps as described above would be used to achieve this. You would “dial up” a compass bearing on the owl’s auditory from two different locations along the trail or road. (While fine-tuning your bearing on the owl you should also estimate the distance the owl is away from your location in case the owl moves and you only get one bearing on it). The next step would be to transfer the compass bearings to a map by plotting your call stations on the map and then lining the orienteering lines on your compass with a north/south line on the map. Using the edge of the compass, draw the intersecting bearing lines on the map and place a dot at the point of intersection to represent the owl’s location. The final step is to obtain UTM coordinates from ArcView/ArcGIS and plug them into a GPS unit if you have one. You can use the “Go to” function on the GPS unit to lead you to the point of detection and hopefully the owl!

# 6.0 Completing Data Forms

## 6.1 Site Search Data Form

The Site Search Form (Figure SOP 2.1) is filled out for each visit to an owl site, regardless of outcome. Fields on the Site Search Form are described below.

**General Information**

Form ID #: This eight-digit number is sequentially assigned to each form filled out based upon the year and which crew performed the site search. The first four numbers correspond to the year. The fifth number corresponds to the crew (PRBO=1 PORE=2 MUWO=3 GOGA=4 MMWD=5 and MCOSD=6). The final three numbers should correspond to the order in which surveys were performed. It is not necessary for the numbers to relate precisely to the sequence of searches, so long as every data sheet is given a unique number. It is advisable to keep a log of the numbers you have already used and how they correspond to dates and locations. This allows a means to track stray data.

Site Name: Fill out the complete name of the site visited. Be sure to distinguish between sites with similar names, e.g., Barnabe Creek and Barnabe North. A look-up table will prompt you with the correct spelling of most locations during data entry.

Owl Site #: “MRN” followed by four numbers. Most sites have been designated with a unique number. This field is automatically filled in from the Site Name selection based on the assigned number in the SitesLUT. Official MRN numbers are assigned and distributed by the CA Department of Fish and Game.

Date: Indicate the date numerically in the format of month/day/year.

Crew: indicate the four or five letter acronym for the survey crew that you are a part of. A look-up table will prompt you.

Recorder: Record your initials here. This allows data managers to efficiently ask the appropriate owler any questions regarding the data. The data recorder identified in the field and in the database should be the same person. If it is not, indicate this in the narrative. Add new initials by clicking on the "Update Initials LUT" button below this field.

Lead Observer Last Name: Record the last name of the site search's most experienced observer.

Other Observer's Initials: Record three letter initials strings separated by spaces for observers other than the lead. Include the recorder. Use consistent initials sequences for each observer. Use prompt to see initials previously used.

#Observers: record the total number of observers that were on the site search.

**Conditions Summary**

Visit Start Time: Indicate the time at which you began actively searching for owls by visually searching, calling, or listening.

Call Start Time: Indicate the time at which you began either playing a tape or simulating spotted owl calls with your voice.

Method: Indicate whether you used voice simulations, a cassette recording broadcast, both of these, or if no call simulations were done. Never leave this field blank. A look-up table prompts for appropriate answers.

Visit End Time: Indicate the time at which you ceased any kind of searching for spotted owls within your search radius of the activity site.

Wind: Use the one adjective that most accurately describes weather conditions typical of the search.

Precipitation: Use the one adjective that most accurately describes weather conditions typical of the search.

Temp: Indicate the most characteristic Fahrenheit scale temperature experienced during the search.

Clouds (%): Estimate the average percentage of the sky obscured by clouds during the site search.

Light: Indicate whether the survey was performed primarily during daylight or during hours of darkness.

**Visit Summary**

Formal Survey: If the effort was part of regular monitoring or inventory, record “yes.” If information was gathered opportunistically, e.g., while camping, hiking, or represents an unofficial visitor’s report, record “no.”

NSO Response: Indicate whether there was a positively identified spotted owl heard or seen during the site search. Do not indicate yes for barred owl detections. Do not indicate yes for “possible” spotted owls. Only record "possible" owls in the narrative.

Other Owl Species Detected: Note the four letter AOU codes for other owl, corvid, or raptor species heard or seen during the survey, e.g., BDOW for Barred Owl, GHOW for Great Horned Owl, WSOW for Western Screech Owl, BNOW for Barn Owl, NPOW for Northern Pygmy Owl, NSWO for Northern Saw-Whet Owl, etc. If a barred owl is detected, document it as fully as possible, preferably with photography. DO NOT INCLUDE 'POSSIBLE' DETECTIONS. These are only appropriate in the narrative.

Was an effort made to see bands?: Please indicate whether observers attempted to look for bands. Indicate "NA" for visits without owls. Indicate "yes" if an attempt was made, even if the view was poor and no bands were seen.

Were owls banded on this visit?: Answer yes only if new bands were placed on an owl's legs during the visit.

Were Mice Offered?: Indicate "yes" if live mice were offered to owls during the visit, regardless of mouse fate.

Mousing Purpose: Indicate why mice were offered to the owls. A look-up table provides appropriate responses.

Total #Mice Taken: Indicate the total number of mice which did not make it back into the cage. Do not include mice offered but which were not taken. Include only the number "added" to the forest.

Bait taken to nest?: Check here if any of the bait mice that you offered were taken to a spotted owl nest.

Total # Detected: Note total number of mature NSO, Nestlings, Branchers, and Fledglings: These fields allow data managers to quickly quantify detections and verify referenced data in the detections subforms. Enter "0" where necessary rather than leave fields blank.

Nest View: Was the view into the nest adequate to see all owls that might be present in it? If you have any doubt, answer "no."

**Owl and Other Raptor Detections**

Species: Use only one row for each individual detected. Record all owl species and all noteworthy diurnal raptors. Use the AOU four letter codes to indicate the species, e.g., SPOW for spotted owl or COHA for Cooper's Hawk.

Sex: Indicate "F" for Female, "M" for Male, or "U" for Unknown.

Tail: Describe NSO tail feathers using "P" for an acuminate point with a white band, "T" for the terminus being worn into a plump triangle, "R" for round and mottled, "S" for tips which are undoubtedly subadult but which you are unable to differentiate further, or "U" for unknown.

Age: Describe NSO age using "A" for Adult, "S1" for 1st year subadult, "S2" for 2nd year subadult, "SA" for a subadult of unknown age, "U" for an unknown adult or subadult, "N" for Nestling, "B" for Brancher, "F" for fledgling, or "J" for unknown age juvenile. For other species "I" may be used for immature.

Time: Indicate the time the raptor was first detected.

Type: Indicate the kind of detection with “A” for Auditory, “V” for Visual. Both may be inscribed in this field in the order of occurrence.

Band Color: Always fill in this field. Include newly banded owls. Write in the color or pattern of the band only if it was positively identified. Write “PRESENT” if you are certain there was a band but were unable to definitely determine the color. Write “NONE” if you gained a good view of both legs and positively confirmed the absence of a color band on both legs. Write “UNKNOWN” if the legs were not adequately seen or if only one leg was seen. DO NOT ENTER PARTIAL COLORS, e.g., only enter "RED" if it was solid.

Tab: Always fill in this field. Indicate the color, “UNKNOWN” if the tab was not definitively identified, "PRESENT" if you were certain there was a tab but could not identify it, or "GONE" if the owl has definitely removed its tab.

Leg: Always fill in this field. Indicate “R” for the owl’s right leg, “L” for the owl’s left leg, "U" for cases where information is unknown, "N" for neither leg (in the case of "NONE" as color).

UTM_E: Record the Universal Transverse Mercator Easting, NAD 83 Zone 10. For the Marin County study area this number should be between 499600 and 545700.

UTM_N: Record the Universal Transverse Mercator Northing, NAD 83 Zone 10. For the Marin County study area this number should be between 4184500 and 4236000.

Meth: Indicate the method used to derive the UTM coordinates. Review the look-up table for options.

Acc: Indicate your estimate of the accuracy of your map or the accuracy given by your GPS unit. Use “80” for accuracy at or below 80 m, use “150” for accuracy at or below 150 m, use “300” for accuracy at or below 300 m, or another figure for higher numbers.

**Mousing Effort**

Mousing Table: Record one row for each mouse offer. Changing mice or changing mouse locations do not constitute a new mouse offer.

Mouse #: Indicate which mouse in the sequence of offers the row represents.

Time Out: Indicate the time at which the mouse was placed within striking range of the owl.

Time Taken: Indicate the time at which the NSO captured the mouse. If the mouse was never captured, place a line through the field to indicate a negative response.

Fate: Always fill in this field. Use the following codes: “E”=ate mouse; “H”=held mouse until observer left or for 1 hour; “C”=cached mouse; “T”=took mouse to owl of opposite sex; “Y”=took mouse to young; “A”=took mouse to owl of opposite sex who took it to young; “N”=took mouse to nest; “I”=ignored mouse until observer left or for 1 hour; “L”=left with mouse, returned or was relocated without it; “X”=left with mouse, not relocated; “W”=left with mouse, was relocated without it but with certainty did not deliver to young or mate “D”=dropped mouse w/o retrieving; or “B”=Bander prevented owl from capturing the mouse. This final field is an important distinction from “I” or “D.”

Fate Time: Indicate the time at which the above fate code became apparent. For "Held" mice this will be the time you last saw the owl with the mouse.

Sex: Indicate the gender of the NSO that either interacted with the mouse or was offered the mouse.

Age: Indicate the age of the NSO that either interacted with the mouse or was offered the mouse.

Behavior/Notes: Briefly indicate exceptional circumstances of any mice. Lengthy details may be included in the Narrative.

**Observational Information**

Place a check mark in all the small white boxes which correspond to events or evidence which happened, were seen, or became apparent during this site search under the categories of Visit Status, Evidence, Nesting Indicators, and Reproductivity.

**Narrative**

This is the most important field in the record of your site search. Narratives are especially important at the end of the season when site status is designated. Write an account of all relevant events which took place during the site search. Include the time of all significant moments of the day. Include directions, landmarks, reasons and reasoning, tools used, unusual circumstances, suggestions and questions. Presume that your audience is someone 20 years into the future who may not understand owl research. Here you are able to document any nuances of your effort which are not captured by the above data fields and explain why your site search was performed in the manner that it was and how the results came about. Also by telling the story of your effort, data managers have a way to double-check the above data entry and solve any difficulties. Consider the narrative as a means by which to avoid a telephone call later in the season asking you to explain why or how you came to the conclusions you came to.

## 6.2 Nest Habitat Data Form

The Nest Habitat Data Form (Figure SOP 2.6) is filled out for each known nest site each year. The measurements and form take about 45 minutes to complete per site and can be filled out at any time after a nest is found, but should be done after the young have fledged if possible to avoid any disturbance. In addition, the nest trees are tagged with aluminum tags (Forestry

## *Northern Spotted Owl Nest Habitat Data Form*

*(attach map location and any photos)*

***Location***

Site Name:__________________________ Owl Site #: ____________________ Year:__________

Observers:____________________ Measurement Date: ________ Tree Tagged? yes / no Tag #________

New Location *(never described before)*? Yes / No

First Year Used: _________ Total # of Seasons SPOW Documented Nesting in this Tree: _______

Number of SPOW Fledged From This Tree (*this season*):_______Is This Number Definitive? Yes / No

GPS Unit Used:________UTM E________ UTM N________ Accuracy _______ Elevation:______meters / feet

***Physical Features***

Aspect: (degrees) Magnetic or True

Slope: _____% Slope Position: bottom / mid-slope / ridgeline / ridgetop

Distance to Water: ____________m (permanent or ephemeral present during breeding season)

Forest Opening:________m Kind____________ *(windfall, glade, outcrop , shrub, etc.)*

Forest Edge:__________m Kind____________ *(meadow, road, reservoir, etc.)*

**Dominant Vegetation at Site** *(circle all that are >33% of the overstory or understory layer)*

Overstory: redwood / Douglas fir / bishop pine / bay / live oak / other ____________________

Understory: fern / hazelnut / coffeeberry / tan oak / huckleberry / herbaceous / other ________

**Nest Features**

Nest Tree Species: redwood / Douglas fir / bishop pine / bay / live oak / other ____________

Nest Type: cavity (top entry or side entry) / platform Nest Tree Alive?___________________

Nest height: ________m Tree height: __________m Diameter at breast height (dbh): ________cm

How was the info gathered ? *(circle any/all used)* ArcView/topo map/compass/clinometer/altimeter/dbh tape

Description of Site *(general habitat, stand description, proximity to main or alternate roosts, nests, etc.)*:__

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

Direction to Roost / Nest *(access trails, gates, landmarks, flagging, distance, etc.)*:__________________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

*Continue on Back if Necessary* 4/5/04

**Figure SOP 2.6.** Nest Habitat Data Form used for recording nest and habitat characteristics for spotted owl monitoring in the San Francisco Bay Area Network.

Suppliers, #25331), stamped to indicate site number and year. Fields on the nest habitat data form are described below.

**Location**

Site Name: Official site names are assigned in the office. If it is a new site, you can suggest a name based on a local geographic feature. If you are unsure whether it is an existing site or a new site, record detailed notes of location and accurately map your location. Cross reference your mapped location against a comprehensive territory map upon returning from the field.

Owl Site #: Official MRN number assigned and distributed by the CA Department of Fish and Game. Some sites have yet to receive a MRN # and are recorded as "None".

Year: Record the current year.

Observers: Record initials of individuals present.

Measurement Date: Record the date the nest tree measurements were collected.

Tree Tagged: Yes, if it was a reused tree that was tagged previously or if you tagged it as a new tree that year. Tag tree at face height on the most accessible side unless nest tree is located directly on a trail. If the latter is the case, tag on side away from trail. Remember to color the aluminum tag black using a permanent marker to reduce its visibility. If it is a reused nest tree, use a nail to etch the last two digits of the new year of use on the old tag or add a new tag. Enter the new tag # in the Tag # field, and describe both tags in the data form comments section.

Tag #: Tag includes MR# then a space followed by the last two digits of the year it was first located, for example: MR001_04. Check trunk of tree at eye level for previous nest tags.

New Location (never before described): Refers to the nest tree not the site. Yes, if it is the first year the nest tree was identified. No, if it is a subsequent year of use.

Total # of Seasons NSO Documented Nesting in this Tree: You can read nest tree tag for this information or check the nest tree forms in the database.

Number of NSO Fledged From This Tree (this season) and Is this Number Definitive?: This is an attempt to avoid underestimating number fledged. If you saw two fledglings on one visit, but only one after that you should note that one fledgling is not definitive and the fledge number is '1', with a note in the comments field about why the number was not definitive. If site was monitored for occupancy and management purposes, the number of fledglings may not be definitive due to the reduced number of surveys these sites receive.

GPS Unit Used: Confirm GPS unit and refer to drop down list on nest form.

UTM E and UTM W: Record UTM coordinates of the nest tree.

Accuracy: Record accuracy of UTM coordinates. The measure of accuracy can be found on GPS unit and will be meters on most units. Record accuracy value in meter units.

Elevation: Obtain elevation from USGS topographic map and use meters as units.

**Physical Features**
Aspect: The compass bearing at which water would flow if you dumped a bucket at the nest tree. Average this over the 50 m around the nest to avoid measuring tiny landscape features. Record whether this bearing is magnetic (no declination set on compass) or true (declinated compass).

Slope: Determined using a clinometer. Crouch down to fern height and look across the tops of the ferns noting the % slope. Take percentages looking downslope and upslope and average them. Double check scales on clinometer by tipping it way up, ensuring that percent scale is recorded and not the degrees scale.

Slope Position: (bottom, mid-slope, ridgeline, or ridgetop). Slope position is general overall location on slope. It is often mid-slope. If the slope drops down from the nest site in all directions, you are on the ridgetop (rare). If the slope goes up from your position in one direction and down in the other three directions, you are on the ridgeline (uncommon).

Distance to water: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. Record whether water is present throughout season or only present during the wet season.

Forest Opening: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. A forest opening for this purpose is defined as an area the sun reaches the ground over a minimum patch of 5 m radius..

Forest Edge: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. Defined as a larger scale change in habitat that creates a forest border.

**Dominant Vegetation at Site**
Overstory and Understory: Identify and record all dominant species that compose >33% by cover of the overstory and understory within 50 m of the nest tree. Overstory classification assumes that a tree receives direct sunlight, and thus its loss will increase light penetration to the forest floor. Understory vegetation may occur at any height secondary to the upper canopy layer, and includes secondary trees, shrubs, and herbs.

**Nest Features**
Nest Tree Species: Determine and record.

Nest Type: Should be either a platform or cavity (also note: top or side entry).

Nest Tree Alive: Yes or No.

Nest Height and Tree Height: Obtained using a clinometer, 50 m tape or pacing, and trigonometry. Directions are included with clinometer. One way is to measure your distance from the tree using either 50 m tape or counting paces far enough so that you are even horizontally with base of the tree. (You can use the clinometer to check this. This distance is your first "side".) Take a clinometer reading at the nest and the top of the tree to get the angles to each from your known distance from the tree. Use the known distance and these to calculate the other "sides" (heights). Remember to add your height to the side/angle/side math. Record an ocular estimate of tree height and nest height to double check your math.

Diameter at breast height (dbh): Measured using dbh tape and recorded in centimeters.

How was the information gathered: Circle all that apply from the list.

Description of Site: General description of general habitat, stand description, proximity to main or alternate roosts, nests, etc. Provide all details needed to orient future field staff to the site.

Direction to Roost/ Nest: Description of access trails, gates, landmarks, flagging, distance, etc. Include detailed descriptions of nesting structure, nest aspect (general bearing of which side of the tree the platform/cavity is on), and state if the platform has disintegrated.

## 6.3 Cooperating with Other Research Activities

### *6.3.1 Documenting West Nile Virus*

Although West Nile Virus has not been found in a non-captive NSO as of May 2008, the virus has been found in captive NSO and in wild Barred Owls. The likelihood of finding a dead or sick NSO with West Nile Virus is low given the brushy locations that are surveyed, but it is possible. Current procedures for handling sick or dead spotted owls suspected of having West Nile Virus are similar to procedures for other birds except the initial contact would be made to the USGS National Wildlife Health Center (West Nile Virus Coordinator, Madison, WI (608) 270-2456).

Any other bird species found during field work that are suspected to have died from West Nile Virus are reported to the California Department of Health Services using their toll-free hotline (877-WNV-BIRD). Since fecal material, saliva, and blood are the most likely sources of viral infection from handling an animal, latex gloves should be worn and if necessary, eye protection. If field staff has been in contact with infected animals or contaminated materials, flushing and washing the exposed area with soap and water is the recommended treatment. All birds should be submitted for testing as soon as possible following discovery and should not be frozen prior to testing. The Centers for Disease Control and Prevention (CDC) website (http://www.cdc.gov/ncidod/dvbid/westnile/index.htm) provides basic information about the disease, maps and statistics on human cases, and links to other government websites for additional information such as county maps and the list of affected bird species.

### *6.3.2 Documenting Sudden Oak Death*

Sudden Oak Death (SOD) has been confirmed in all areas of the study area. *Phytophthora ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients (Moritz et al. 2008). Other secondary decay organisms such as beetles and fungi often move in after the tree is infected.

Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death. Many other diseases cause similar symptoms; therefore, the presence of *P. ramorum* can only be confirmed by a laboratory test.

During field surveys, researchers should look for tanoaks or coast live oaks showing the symptoms of SOD. Researchers should be familiar with the document "How to recognize symptoms caused by diseases caused by *P. ramorum* causal agent of Sudden Oak Death" (Garbelotto et al. 2002). If symptoms are noted in previously undocumented areas, researchers should inform both the PORE and GOGA Supervisory Botanists who may conduct further testing to confirm SOD.

An SOD Severity Index will be established at each NSO site monitored each year adapted from rapid assessment methods developed by Moritz et al. 2008. The severity index evaluates affected tanoaks (*Lithocarpus densiflorus*) and coast live oaks (*Quercus agrifolia*) on a scale of 0 (no SOD present) to 10 (>95% canopy cover). The severity index considers both the overstory and understory within a circular plot (50 m radius) and includes both dead and symptomatic vegetation. Ratings of 8-10 consider larger plots at 75 m to 100 m in radius.

Oak trees classified within the overstory may be a dominant or minor component of the overstory or co-dominant with other tree species, such as redwood or Douglas fir. Overstory classification assumes that a tree receives direct sunlight, and thus its death will increase light penetration to the forest floor. Understory trees may occur at any height secondary to the upper canopy layer. Both overstory and understory trees must be ≥1 inch dbh for consideration in the rating evaluation.

The center point for the SOD severity index rating will be at the established activity centers, such as nest trees, for each NSO site monitored. The SOD severity index will be entered into the STATUS table of the NSO monitoring database (see SOP 4: Data Management Handbook). Final status records are entered for each NSO site monitored each year and include geographic UTM coordinates of nest trees or activity centers. The center point for each SOD severity index rating should match the UTM coordinates in the corresponding STATUS record.

For sites where a defined activity center is not found or is questionable, field staff may opt not to develop an SOD severity index. For example, this may occur at unoccupied sites or sites with single unknown status.

A detailed guide to the SOD severity index rating is presented in Table SOP 2.1.

**Table SOP 2.1.** Guide to SOD severity index rating on 0-10 scale. Data is collected within a circular plot (50 m radius) unless otherwise noted.

| Rating | Overstory Dead[1] | | Overstory Sympt / Dead[2] | | Understory Dead | | Understory Sympt / Dead |
|---|---|---|---|---|---|---|---|
| 0 | none | AND | None | AND | none | AND | none |
| 1 | none | AND | None | AND | 1-2 tr[3] | OR | 1-4 tr |
| 2 | none | OR | < 5% CC[4] | AND/OR | 3-4 tr | OR | 5-6 tr |
| 3 | < 5% CC | OR | ≥ 5% CC | AND/OR | ≥ 5 tr | OR | ≥ 7 tr |
| 4 | ≥ 5% CC | OR | ≥ 25% CC | | NA | | |
| 5 | ≥ 25% CC | OR | ≥ 50% CC | | NA | | |
| 6 | ≥ 50% CC | OR | ≥ 75% CC | | NA | | |
| 7 | ≥ 75% CC | OR | ≥ 95% CC | | NA | | |
| 8 | ≥ 95% CC | OR | ≥ 95% CC in area ≥ 75 m r | | NA | | |
| 9 | ≥ 95% CC in area ≥ 75 m r | OR | ≥ 95% CC in area ≥ 100 m r | | NA | | |
| 10 | > 95% CC in area ≥ 100 m r | | NA | | NA | | |

1. Dead is standing dead or fallen, stump sprouting ignored.
2. Sympt / Dead includes the total of both dead and symptomatic trees.
3. Trees (tr) are defined as woody stems ≥ 1 inch DBH.
4. CC is canopy cover

## 7.0 Literature Cited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# SOP 3. Status Designations

*Version 1.3*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| July 2001 | 12/8/07 | D. Adams | Format, slight content revisions | Respond to reviewer comments and format standards | 1.1 |
| 1.1 | 5/4/08 | D. Adams, H. Jensen, D. Press | Format, content revisions, additions | Respond to reviewer comments and format standards | 1.2 |
| 1.3 | 4/19/10 | D. Press | Format revisions and minor edits. Mention of USFWS 2010 protocol. Added Literature Cited section. | To meet current formatting guidelines and peer review comments. | 1.3 |

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This standard operating procedure (SOP) document describes the protocol used to determine the annual occupancy, nesting, and reproductivity status of northern spotted owls based on data collected during surveys on federal lands in Marin County, California. Survey methods are described in SOP 2: Standard Field Procedures. This SOP was adapted from existing monitoring protocols, including the "Spotted Owl Monitoring Protocols for Demographic Studies" (PNW Protocol; Forsman 1995), the USFWS "Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls" (USFWS Protocol; USFWS 1992), and the Marin Modified Field Protocol (Fehring et al. 2001).

In 2001, the Marin County spotted owl monitoring program designed a monitoring protocol, the "Marin Modified Field Protocol", in response to observed behavioral changes in northern spotted owls due to repeated mousing. The modified protocol was based primarily on the PNW Protocol and used the advantage of the accessibility of the owl sites to increase the search effort and the number of visits in order to decrease the number of mice fed to owls, while striving to obtain the same accurate measure of owl reproductive status and success in other monitored areas. This SOP formally replaces the Marin Modified Field Protocol as the standard followed by the SFAN NSO monitoring program.

Modifications to the standard, range-wide protocols (PNW and USFWS Protocols) are identified as underlined text. Some original text has been lined out but is retained for comparison purposes. All modifications are noted with a number corresponding to the endnote. Because some of the text is taken directly from the range-wide protocols, there are references to different survey periods in Washington, Oregon, and California, which is also retained for comparison purposes.

The two-letter codes following each status designation refer to the codes used in the program database in the status table and form. All sites or areas where management concerns are paramount and are not part of the long-term monitoring program should be surveyed according to the USFWS Protocol. Occupancy and reproductive status requirements differ, so refer to the appropriate protocol.

The PNW Protocol emphasizes the need to differentiate spotted owls from barred owls and spotted/barred hybrids. As this need increases in Marin County, the vigilance is important to document the continuing range expansion of the barred owl.

Research on spotted owls over the last decade has raised concerns regarding the effectiveness of the USFWS 1992 survey protocol, particularly those which do not result in spotted owl detections, most likely due to barred owl presence. An interagency Barred Owl Work Group and its Survey Protocol Subcommitte, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft "2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls" (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

# 1.0 Survey Site Status Determination

Figure SOP 3.1 illustrates the five levels of status that must be determined at each NSO territory in each year that a territory is monitored.

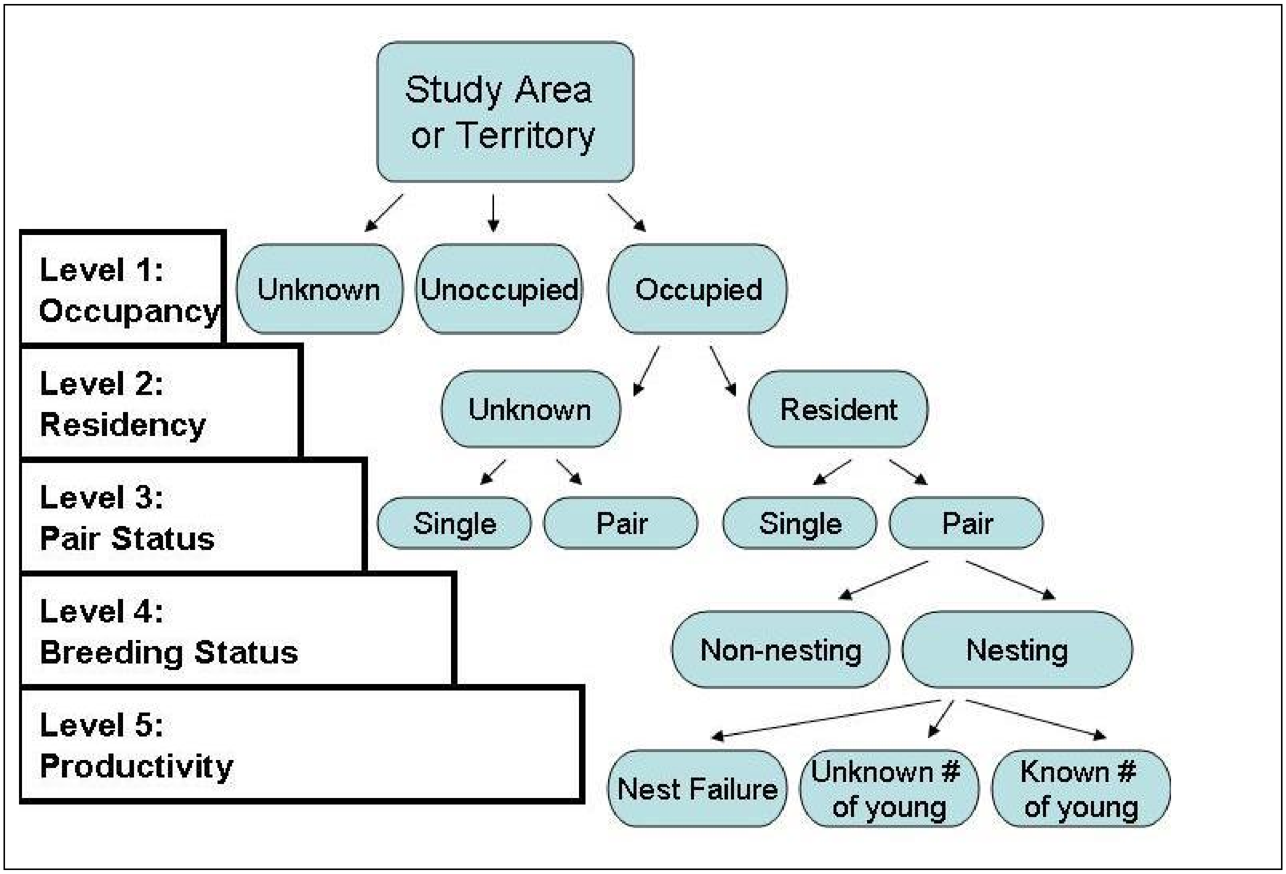


**Figure SOP 3.1.** The five levels of NSO territory status and study area designation.

## 1.1 Level 1 Occupancy Status

**OCCUPIED:** A survey area or site will be considered Occupied if at any time (within or outside of breeding season) a spotted owl is detected within the survey area or site (see Level 2).

**UNOCCUPIED (UO):** A minimum of 3 visits per year are required to establish that an area is Unoccupied (two-year survey; Marin Modified and PNW Protocol). This determination is based on a two-year survey. For example, if spotted owls are not detected at a site without previous historical data or the site has a gap in historical data, a two-year survey (min. three visits/yr) is needed. If no spotted owls are detected the first year, the site Occupancy status would remain Unknown (UK) until a second year of surveys confirmed that the site is Unoccupied.

**UNKNOWN (UK):**
Two definitions apply:

Definition 1: Applied to areas or territories with no historical site data in which no spotted owls were detected during the minimum three visits/breeding season. An Unknown status should be applied to the area until a second consecutive year of surveys has been completed. A second year of surveys (minimum three visits/breeding season) with no owl detections needs to be completed before the site is determined Unoccupied (UO).

Definition 2: Areas that have no spotted owl detections and that meet the minimum of three visit/year during the second year of surveys, but have an incomplete (<3 visits/breeding season) survey effort the previous year will be considered Unknown.

**INCOMPLETE (IC):** Applied to areas where fewer than three surveys occurred during a single breeding season and no spotted owls were detected. In these cases the overall status code would be Incomplete, Unknown (UK) would be used for pair status and Not Applicable (NA) for Nesting status and Reproduction status.

**NOT SURVEYED (NS):** Applied to areas that were not surveyed during the breeding season. Pair, nesting, and reproductive status would be Not Applicable (NA). Since status forms are not frequently completed if a site was not surveyed during the breeding season, a status of Not Surveyed is rarely used.

## 1.2 Level 2 Residency and Level 3 Pair Status

**Occupied Resident:**

**PAIR (PR):** A site will be considered occupied by a **Pair** if any of the following occurs:

1. Two marked individuals that have been paired in previous years are found alive on one or more occasions between March 1 and September 30 anywhere within a 1 mile radius of the traditional site center. There is no requirement that they be seen near each other, as long as they appear to be occupying the historical site. In cases were both pair members are confirmed alive within the historic range, but where one or both members are occasionally found roosting with other owls (not unusual in non-nesting years) we will usually classify the two historic pair members as a Pair.*

2. In cases where owls are unmarked or their bands are not seen, owls will be classified as a Pair if a male and female are heard and/or observed within 0.5 mile of each other on one or more day visits or on two or more night visits. Male and female locations do not need to occur on the same visit. For example, Pair status would be assumed if a male and female were heard one night, a female was heard another night, and a male on another night.*

3. A male takes a mouse to a female. To be called a spotted owl Pair the female must be either: 1) seen or, 2) heard giving definite spotted owl calls. Otherwise the site should be listed as occupied by a Pair of undetermined species composition.

4. A female is detected on a nest. If both she and the male are not seen (or heard giving definite spotted owl calls), then it should be called a Pair of undetermined species composition.

5. One or both adults are seen with young. To be called a spotted owl Pair, both adults must be seen, or the young must be seen late enough in the season to examine their plumage to insure they are not hybrids.

6. If juveniles in advanced stages of plumage development are observed such that you are sure as to their species (a trained observer can identify hybrids once the feathers on the breast and abdomen develop in late July and August).

Because of the potential for hybridization, it is becoming increasingly important to confirm the identity of both pair members. In the case of females heard on the nest, you need to be aware that the contact calls of female barred owls and spotted owls are essentially identical. Thus, if there is any suspicion that barred owls are in the area, you should definitely return to the site to confirm the species of the female. (Marin Modified and PNW Protocol)

**NOTE that USFWS protocol defines pair status a little differently in terms of the first and second criteria of the PNW and Marin Modified Protocols (USFWS below):*

1. *A **male and female are heard and/or observed** (either initially or through their movement) in proximity (**<1/4 mile apart**) to each other on the same visit….*

**RESIDENT SINGLE (RS):**
Resident Single status is established by the presence or response of a single owl within the same general area on three or more occasions during a breeding season, with no response by an owl of the opposite sex after at least three complete surveys. Multiple responses by single owls in the same general area over several years are also acceptable for defining Resident Singles. (two or more responses in one year and one or more responses in another year should constitute a Resident Single). Determining if responses occur within the same general area should be based on topography and the locations of adjacent owl activity areas.

If a single owl is detected, at least two additional visits should be conducted to determine if a pair is present. These visits should all take place during the breeding season in which the first response is heard. (Marin Modified, PNW, and USFWS Protocol)

**<u>Occupied Unknown</u>**
**PAIR UNKNOWN (PU):** Two owls, pair status unknown. The presence or response of two owls of the opposite sex where pair status cannot be determined and where at least one member must meet the resident single requirements *or site had pair occupancy the previous breeding season*. (USFWS protocol; *Marin 2007 addition*)

**SINGLE UNKNOWN (SU):** The response of a male and/or female which does not meet any of the above category definitions (USFWS protocol for Unknown Status). Also included would be cases where owls could not be sexed based on responses and/or unbanded non-vocal owls. Owls cannot be positively sexed based on barking and contact calls. Sex should be considered unknown until a sexable call such as a four note location call or series hoot is detected.

### 1.3 Level 4 Breeding/Nesting Status

Nesting status surveys may be conducted from April 1 - May 31 in Oregon and California and April 1 - June 15 in Washington or at high elevations in Oregon. However, if females are detected on the nest prior to these dates, then those visits can be counted as well. To avoid missing a late nesting attempt it is important that visits not all take place in early April. If early visits do not provide evidence of nesting, at least one visit should take place after April 15 in California and Oregon and May 1 in Washington and at higher elevations in Oregon. Species of the male and female must be clearly established to avoid any possibility of confusing hybrids and spotted owls.

To minimize mousing use additional visits, extensive searching and careful observation of owl behavior to locate nests. Inspect likely platforms and look for feathers plucked from the brood patch which are often visible around the edge of the nest. If nesting is suspected but the nest cannot be located, use the mousing protocol to locate the nest.[1]

**Mousing**: One of the techniques used to assess nesting status will be to feed live mice to owls and then observe the owls to see what they do with the mice. Protocol for this procedure is as follows:

1. Locate one or both members of a pair during the day and offer them at least four mice. Allow at least a 5-minute pause between mousing attempts. Describe what the owls do with each mouse (eat, ignore, cache, carry to nest, etc.). If only a single owl is located, the same protocol is followed. If you are unsure whether a mouse was eaten or cached, but are sure that it was not carried to a nest or young, be sure to so indicate. In other words, don't just record that you have no idea what happened to a mouse when you are sure that it was not taken to a nest or to young owls.

2. If the owl(s) cache mice or simply roost with a mouse for prolonged periods, then it is okay to stop mousing after three mice are fed.

3. If an owl takes a mouse and flies away, follow it as closely as possible to determine where it takes the mouse. If you are unable to follow the owl, and don't know if it took the mouse to a nest or fledged young then that mouse should not be counted towards the requirements of the protocol. Be ready to run, as owls sometimes carry mice several hundred yards to reach their nests or young.

**In order to avoid habituating owls to humans, do not feed any more mice than necessary to determine nest location and nest status.**

**NESTING PAIR (NP):** Owls will be classified as a Nesting Pair if any of the following are observed:

[1] This statement is added to clarify the methods for locating nests.

1. A female is detected on a nest or either a male or female carries prey into a nest on two or more occasions within the dates specified above. After April 15 in California and Oregon and May 1 in Washington, nesting may be confirmed on the basis of only one occasion where a female is observed on a nest or when a male or female carries prey into a nest. The two-visit protocol for confirmation of nesting is dropped after the specified dates because there is little chance owls will continue to "play house" (i.e., sit in the nest without actually laying eggs) after the first two or three weeks of the nesting period. All fecundity monitoring sites in Marin County should be should be visited between April 15 and May 1 to determine nesting status.[2]

2. A female possesses a well-developed brood patch when examined in hand during April 1 - June 30. Presence of a small bare area or molting feathers on the abdomen should not be counted as a brood patch. This is a judgment call. When in doubt use other criteria such as results of mousing or observations of roosting. Describe the brood patch, including dimensions and visual appearance of skin.

3. Young owls are observed in the presence of at least one adult. Because of the possibility of hybridization, an effort should be made to confirm identity of both parents, although this will not be absolutely required if the species of juveniles can be conclusively determined. Always examine juveniles carefully to make sure that they are not juvenile barred owls or hybrids.

4. Spotted owl eggs, eggshells or remains of nestlings are found in or under a nest.

**NON-NESTING (NN):** Confirmation of Non-Nesting status must take place before June 1 in California and Oregon and June 15 in Washington. The June 15 cutoff may also be used at higher elevations in Oregon if deemed biologically appropriate. With these cutoffs, some pairs will inevitably be classified as Non-Nesting, when they in fact nested and failed. This means that estimates of the proportion of the population that nests may be somewhat underestimated because the estimate will include some pairs that nested and failed early in the season.

To classify a pair/female as Non-Nesting, the four-mouse protocol should be conducted on one or both members of the pair with no evidence of nesting on at least two occasions. At least two mice must be taken to be considered a valid mousing attempt.

If visits to document nesting are made in April they should be at least 3 weeks apart so that late nesting attempts will not be overlooked. Visits to determine nesting status in May or early June may be done at any interval, including consecutive days. One-day intervals between nesting visits are permissible later in the season because there is little chance that a late nesting attempt will be overlooked during that period.

[2] This statement is added for Marin County surveyors in order to maximize our chances of determining Non-Nesting status based on observing roosting females (See #3 under Non-Nesting Status).

Pairs or single females that are not checked at least twice before June 1 in California and Oregon and June 15 in Washington should be listed as "nesting status unknown". Exceptions to this two-visit protocol are:

1. Female does not possess a brood patch when examined in hand between April 1 and June 15. (If this occurs, non-nesting status can be confirmed based on 1 visit.)

2. Females believed to be Non-Nesting based on one visit between April 15 and June 1, and which then cannot be located despite repeated return visits to the area. Cases like this are not uncommon in poor nesting years, when pairs briefly return to their traditional nest areas, then split up and become difficult to locate.

3. Females observed roosting for 60 minutes or more between April 15 and May 1 [3], showing no sign of attachment to a nest or young, may be classified as Non-Nesting based on a single visit. Females should normally be incubating eggs or brooding young during this period. This technique should not be used for confirmation of nesting after May 1, as it is common for females with well- developed nestlings to remain out of the nest for prolonged periods. When possible complete a second non-nesting confirmation visit to make sure.

**NEST FAILURE (NF):** (No young are produced)
<u>All nesting outcomes in Marin County are based on the view into the nest. Nests where the female is visible when incubating eggs are classified as “visible nests”. Nests with no view into the nest are called “non-visible nests”. Once a nest is located, weekly visits are required to observe activity on the nest such as females incubating or nestling activity. Visits near the expected fledge date are especially important. Spotting scopes and extended periods of observation are used on all nests. Detailed notes about the presence or absence of whitewash at the base of the nest tree are needed to support the following conclusions.</u>

- <u>A **visible** nest is classified as a Nest Failure if, after positive confirmation of nesting there is no female incubating or nestling activity observed at the nest. Two additional visits are required to ensure that no nestlings were obscured and that no nestling fledged between visits.</u>

- <u>A **non-visible** nest is classified as a Nest Failure if the nest is visited on 3 occasions near the expected fledge date and no fledglings are observed. The third visit should be a mousing visit (4 mouse protocol with at least 2 mice taken to qualify as a test).</u>[4]

[3] The PNW Protocol requires that a female be observed for 30 minutes between April 15 and May 15. The length of observation has been changed to 60 minutes because nesting females have been observed off the nest for longer than 30 minutes in the mild climate of Marin. The dates have been changed to April 15 - May 1 because it appears that this is the 2-week window in Marin when all females will be either incubating eggs or brooding chicks that are less than 2 weeks old. Both changes are attempts at being as conservative as possible because we are relying mainly on this method for determining non-nesting.
[4] The PNW protocol requires that failed nests are confirmed with either two mousing visits (at least two mice eaten or cached), previously nesting owls cannot be relocated, or a combination of the two. The modification to this is an effort to capitalize on the fact that most of the nests in Marin County are platform nests and can be observed with a

## 1.4 Level 5 Productivity

**NESTING: YOUNG PRODUCED (NY):**
This measure of reproduction is the most important measure, as it is the basis for estimates of fecundity. The Number of Young produced is averaged for <u>all</u> females whether they are paired or not. Because fecundity is sometimes subdivided by age class (S1, S2, adult) it is critical that age of each male and female be determined, even if that requires repeated visits to document.

The measure of reproduction is the number of young which leave the nest. It is not permissible to count "branchers" (i.e., young owls sitting on branches in the nest tree) unless you are sure that there are no other young hidden in the nest. The concern with counts of branchers is that you may overlook young that are still hidden in a nest.

**Pairs or single females (visible and non-visible nests) will be classified as producing no young if**:

1. They are confirmed to be non-nesting based on protocols for determination of nesting status (above).

2. ~~They are moused to protocol on 2 or more occasions before 31 August, with no sign of young. This may include any combination of reproductive status visits and/or fecundity visits. For example, if a single visit in late May suggests no young produced (e.g., adults eat or cache all mice) this could be combined with a single visit later in the summer which also indicates no young produced.~~

3. Female is observed and designated as non-nesting on one or more occasions in April-May (April 1 -June 15 in Washington), but neither she nor her mate can be relocated later in the summer, despite repeated attempts (minimum of two) to relocate them. As a result, they cannot be moused to determine numbers of young produced. This change to the protocol is needed to address the behavior of some non-nesting owls or owls that nest and fail - they sometimes become difficult to locate and cannot be confirmed as having produced no young.

**The number of young produced is determined as follows:**

A pair is classified as producing young if at least one fledgling owl is observed; observations of nestlings or branchers do not count. For pairs that produce young, brood counts may take place anytime after the young fledge until August 31. However, a determined effort should be made to count the number of young produced as early as possible after broods fledge, preferably before June 30 in Oregon and July 15 in Washington. The objective is to document the number of young produced before any mortality occurs.

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scope. In addition, our required weekly visits to visible nests make it less likely that young can fledge without being observed. The requirement to search under the nest tree for evidence is based on observations that there is usually a large amount of whitewash produced by the young before they can fly well and move away from the nest tree. Note there is still a mousing requirement for non-visible nests that are suspected of failing.

~~After the first occasion when young are counted, at least one follow-up visit should be made to insure that all young were observed on the first visit. If owlets are found under a known or suspected nest tree in late May or June, then the follow-up visit to confirm the number of young fledged should take place at least 3 days later to make sure that all young have time to leave the nest. In all other situations, the 3-day interval between the first and second visit is not required (i.e., visits can be as close as 1 day apart).~~

~~To estimate the number of young produced you should offer 4 mice to one or both adults on both visits, and count the maximum number of owlets that are seen or heard. A visit counts for determination of number of young produced, as long as an adult takes at least 1 of the 4 mice offered.~~

For pairs that produce young, brood counts occur during the weekly nest visit which first detects all nestling owls out of the nest. The objective is to document the number of young produced before any mortality occurs. All young owls observed in visible nests should be located again once they are out of the nest. Use prompt timing of visits and extensive search efforts to locate young close to the nest tree. Look for evidence such as whitewash trails or parental behavior to provide clues about the location of recently fledged owls. Listen for the fledgling begging whistle which can be very helpful for locating and clarifying the number of fledglings. The closer to the expected fledge date, the closer the fledglings will be to the nest tree and the smaller the search area.

For **visible** nests, the brood count will be defined as the number of young observed both in the nest and after they leave the nest. This number must match on two visits or a mousing visit is required.

For **non-visible** nests, visit the nest as close as possible to the estimated fledging date and follow the guidelines below. If a definitive fledgling count cannot be obtained from observation, use mousing to verify.

> If **zero** fledglings are observed, a total of three visits are required near the estimated fledging date with mousing on the third visit (four-mouse protocol).
>
> If **one** fledgling is observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.
>
> If **two** fledglings are observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.
>
> If **three** fledglings are observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.[5]

[5] The PNW Protocol requires that both counts of fledglings are estimated by offering the adult(s) 4 mice. The modification to this is again an effort to capitalize on the large number of visible platform nests. It is possible that we could undercount fledglings without the use of mice. However, the fact that we are checking the nests weekly

If dead owlets are found under a known nest tree they will not be counted as fledged unless there is some flight feather development.[6]

# 2.0 Status Designation Database Fields

For each spotted owl site monitored, Occupancy status, Nesting status, and Reproductive status designations are assigned in the database to represent the highest level of knowledge of that site for that year for each category. A Final status determination represents the highest degree of each of these three categories. The status designations are entered into the master database using two letter codes, noted below in parentheses.

Final Status (database field "Status") possibilities include:

- Survey Incomplete (IC)
- Not Surveyed (NS)
- Unoccupied (UO)
- Unknown (UK)
- Resident Single (RS)
- Single Unknown (SU)
- Pair (PR)
- Pair Unknown (PU)
- Nesting Pair (NP)
- Non-Nesting Pair (NN)
- Nesting Failure (NF)
- Nesting: Young Produced (NY)

Occupancy Status (database field "PAIRSTAT") possibilities include:

- Not Surveyed (NS)
- Unoccupied (UO)
- Unknown (UK)
- Resident Single (RS)
- Single Unknown (SU)
- Pair (PR)
- Pair Unknown (PU)

Nesting Status (database field "NESTSTAT") possibilities include:

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will allow us to locate more fledglings before mortality occurs. Note that mousing is used if multiple counts are not matching or if the second count is less than either the first count or the number of nestlings.

[6] The PNW Protocol Addendum states that all young found dead on the ground are to be counted as fledged regardless of their position relative to the nest tree. The modification is added to address immature young which have either fallen or been preyed upon and ended up under the nest tree. The majority of nests in Marin County are platform nests and more young may fall from these nests before fledging. These young have no chance of survival (and may have been dead when they hit the ground) and should not be counted as fledged.

- Not Applicable (NA) – Survey Incomplete (IC) or Occupancy status is determined as Not Surveyed (NS), Unoccupied (UO), Resident Single (RS) (male), or Single Unknown (SU)
- Unknown (UK) – Nesting Status of owls cannot be determined according to protocol or Occupancy status is Unknown (UK) or Pair Unknown (PU)
- Nesting Pair (NP)
- Non-Nesting Pair (NN) – applicable for owl pairs and Resident Single (RS) females

Reproductive Status (database field "REPROSTAT") possibilities include:

- Not Applicable (NA) –Occupancy status is determined as Survey Incomplete (IC), Not Surveyed (NS), Unoccupied (UO), Resident Single (RS) (male), or Single Unknown (SU)
- Unknown (UK) –nesting is confirmed but reproductive status of owls cannot be determined according to protocol or when Nest Occupancy status is unknown
- Nesting Pair (NP)
- Non-Nesting Pair (NN) – applicable for owl pairs and Resident Single (RS) females
- Nesting Failure (NF)
- Nesting: Young Produced (NY) – fledglings must be observed; nestlings and branchers do not count

The database status records also note the annual status for each site as determined by the USFWS and PNW protocols. Determinations of the USFWS and PNW status designations may differ from the status designation determinations based on this SOP and therefore must be referenced for accuracy. Database codes are not used for these status designation fields.

Available status designations according to the USFWS protocol (database field "USFWSSTAT") include:

- Survey Incomplete
- Not Surveyed
- Unoccupied
- Unknown
- Resident Single
- Pair
- Pair Unknown
- Nesting Pair
- Non-Nesting Pair
- Nesting: Young Produced

Available status designations according to the PNW protocol (database field "PNWSTAT") include:

- Survey Incomplete
- Not Surveyed
- Unoccupied
- Unknown

- Resident Single
- Pair
- Nesting Pair
- Non-Nesting Pair
- Nesting Failure
- Nesting: Young Produced

Note that Single Unknown is not a permissible status designation for the USFWS and PNW protocols. Nesting Failure is not an option under the USWFS protocol, and Pair Unknown is not an option under the PNW protocol. The field "MARINSTATUS" is the text equal to the code in the "Status" field and may be used as a comparison to the USWFS and PNW status designations.

During spotted owl inventory years, the USFWS protocol has been and will be used for all status determinations.

## 3.0 Literature Cited

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U. S. Fish and Wildlife Service (USFWS). 1992. Protocol for surveying proposed management activities that may impact northern spotted owls. Revised March 17, 1992. Unpublished.

U. S. Fish and Wildlife Service (USFWS). 2010. 2010 Protocol for surveying proposed management activities that may impact northern spotted owls. Revised February 18, 2010. Unpublished.

# SOP 4. Data Management Handbook

*Version 1.2*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| | Aug. 2000 | Daniel George | | | |
| | Aug. 2004 | Dawn Adams | | | |
| | Sept. 2007 | Dawn Adams | Reformatted | To meet new formatting guidelines. | 1.0 |
| 1.0 | May 2008 | David Press | Edited and updated | More thorough documentation and implementation of new data management strategies | 1.1 |
| 1.1 | March 2010 | David Press | Minor text and formatting edits. Added Literature Cited section. Converted database object descriptions to table. | In preparation for final protocol submission | 1,2 |

# Contents

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Two critical long-term goals of the San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program (I&M) are to:

- integrate natural resource inventory and monitoring information into National Park Service (NPS) planning, management, and decision making

- share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives

For the northern spotted owl (NSO) monitoring program to meet I&M Program goals, a detailed management plan is needed to ensure data quality, interpretability, security, longevity and availability.

This SOP describes how the monitoring protocol meets these data management objectives through data entry specifications, database design, quality assurance and control measures, metadata development, data maintenance, data storage, and data archiving. In this SOP, particular attention is paid to the procedures all project staff must follow to learn how to enter, update, and manage data for the NSO monitoring database. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the SFAN monitoring program are detailed in the program's Data Management Plan (Press 2005).

# 1.0 Database Design

The NSO monitoring program has continued the use of a monitoring database developed in 2000 prior to incorporation within the I&M Program. The database is maintained in MS Access XP with similarities to the design concept of the Natural Resource Database Template (NRDT), an application developed by the NPS Natural Resource Inventory and Monitoring Program. As with the NRDT, data organization is based on the concept of a survey, or event, occurring at a specified date, time, and location, in this case a spotted owl territory, which is further described in a locations table. The project database does not comply with NRDT standards because not all core tables and naming conventions are utilized. However, the database has served the project staff well, and there are no current plans to convert the database to meet NRDT compliance.

The program database consists of a single master database, titled NSOMASTERXP, which contains all tables, forms, queries, and reports. Satellite databases are created at the beginning of each season for each project team, including Golden Gate National Recreation Area (GOGA), Point Reyes National Seashore (PORE), and PRBO Conservation Science (PRBO). The satellite databases retain the structure of the master database, but with the field data tables left empty. At the end of the field season, the satellite data are uploaded into the master database, archived, and copies of the master database are distributed back to the project teams.

Figure SOP 4.1 shows the relationships among the core tables in the database. Data related to the area surveyed, which can be an existing territory or potential habitat, are entered into the SEARCH table. The SEARCH table is the primary data table, equivalent to tbl_Events in the NRDT. Multiple survey events can be associated with one territory location. If owls are observed

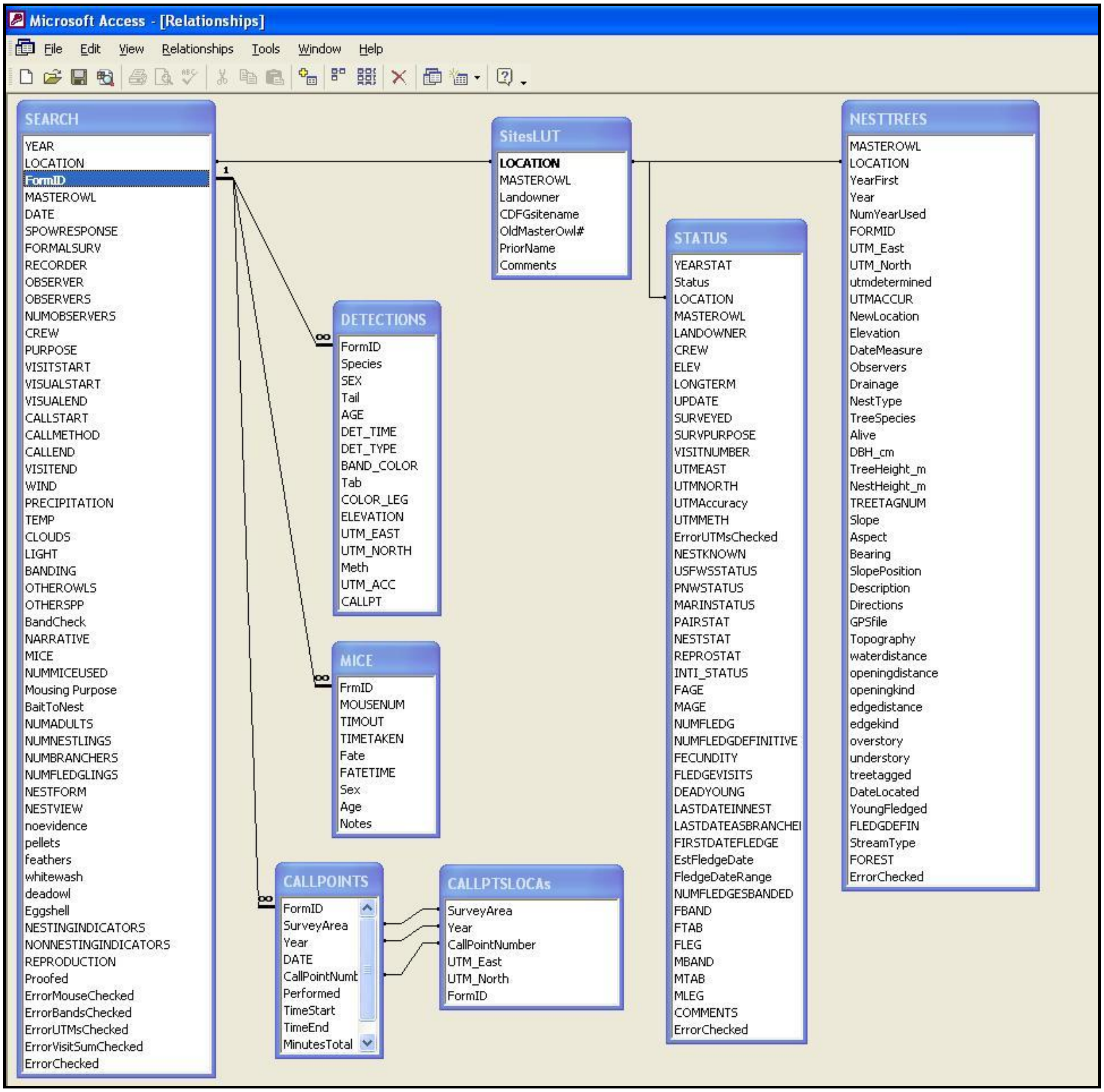


**Figure SOP 4.1.** Relationships among the NSOMASTERXP.mdb database core tables.

during the survey, details are recorded in the DETECTIONS table. Detection information collected includes UTM coordinates (via GPS if possible) for each owl species. Data are also recorded if no owls are observed so that negative survey results are tracked. If mice are used during the survey, details on how long each mouse is offered and disposition of mouse is recorded in the MICE table, which is linked to the SEARCH table. If the survey is for inventory purposes or in a new territory, call points may be used during the survey. Information on call points and their UTM coordinates are recorded in the CALLPOINTS and CALLPTSLOCAs tables. The SEARCH table is linked to the DETECTIONS, MICE, and CALLPOINTS tables by the unique FormID field in one-to-many relationships. The FormID is an eight-digit number sequentially assigned to each field form based upon the survey year and the crew that performed the survey. See SOP 2: Standard Field Procedures for more details.

If a nest is observed at a territory, field data collected at the end of the season on the nest location and nest habitat are entered in the NESTTREES table. Nest tree data are entered for each site where nests were located each year, even if a nest is re-used within a particular territory.

Additional tables include OWLBANDS which stores data on all the banded owls within the survey area (approximately 110); and the STATUS table which stores site and year summary data created at the end of the season after reviewing all the detection information gathered at each activity site.

### 1.1 Tables

If a table's title is in all capital letters it is a core table essential to the operation of the database. Look-up table are noted with “LUT” at the end of each table name. Altering the title or field names will require additional edits to associated forms, queries, and possibly macros. Additionally, any changes made to table design within a satellite database may cause errors in the process of appending records to the master database. As such, only the SFAN Data Manager should perform edits to the core database structure, with thorough documentation of the changes made. Complete database table descriptions are provided in Table SOP 4.1.

### 1.2 Queries

If a query's title is in all capital letters it is a core table essential to the operation of the database. Altering the title or field names will require additional edits to associated forms, queries, and possibly macros. If the core queries are edited or deleted, the database may no longer be able to group data in ways that some forms require. Additionally, any query with the word "ERROR" in the title may depend on other queries with the word "ERROR" in the title or may be used by a macro, and making changes may require changes in other queries or macros. As such, only the SFAN Data Manager should perform edits to the core queries, with thorough documentation of the changes made. Database query descriptions are provided in Table SOP 4.2.

### 1.3 Macros

Macros represent custom strings of commands. Almost all of the macros in the database are commands performed when different buttons in the database are used. Database macro descriptions are provided in Table SOP 4.3.

### 1.4 Forms

All of the forms in the database are essential to the operation of data entry. Those in all capital letters are primary forms, those in lowercase either provide functions within the primary forms or perform secondary functions like printing. Database form descriptions are provided in Table SOP 4.4.

**Table SOP 4.1.** NSO monitoring database table descriptions.

| Database Table Name | Description |
|---|---|
| BandColorLUT | Look-up Table which has all Band Colors already entered. Used by the Detection subform within the SITESEARCH form and by the BANDING and STATUS forms. |
| BlankDatasheet | Used to create dummy fields for PrintBlank forms. |
| CALLPOINTS | Where data are stored for call points which are performed. Data entered into the CallPtPerformSubForm, a subform of the SITESEARCH form, are stored in this table. |
| CALLPTSLOCAs | Where data are stored for the UTM locations of call points. Data entered into the CallPointSubForm, a subform of the InventoryCallPoints form, are stored in this table. |
| DETECTIONS | Where data for individual “Owl and other raptor detections” are stored. |
| InitialsLUT | Where data are stored for observer initials. New records are created from the “Initials” form which comes up when the “Update Observers’ Initials LUT” button is used. |
| LandownerLUT | Lists codes for Marin County landowners. Used by the Combo-box for the “Landowner” field on the STATUS form and in the SitesLUT table. |
| LookUp | Home for a series of codes used by many combo-boxes in all forms. |
| MICE | Where data are stored when mouse offer records are entered in the “MouseSub” within the SITESEARCH form |
| NESTTREES | Where data are stored for all nest tree records entered in the NESTTREES form. |
| OWLBAND | Where all band records are stored when data are entered in the BANDING form. |
| SEARCH | Where data entered into the SITESEARCH form are stored. The SEARCH table is the database’s primary data table. It contains the FormID number, location, date and observer information, visit times, conditions summary, visit summary and narrative fields. Data entered into the subforms are stored in DETECTIONS, MICE, and CALLPOINTS sub-tables. The SEARCH table has a one-to-many relationship to the sub-tables, joined by the FormID, allowing variable numbers of records in the sub-tables to be associated with one site visit. |
| SitesLUT | A list of locations and owl activity site numbers (MRN#) used by several combo-boxes. The MRN# site numbers are assigned by the California Department of Fish and Game. Also contains records for previous names or numbers used at the activity site. Assists in keeping records standard. |
| STATUS | Where data entered into the STATUS form are stored. Contains a summary of an activity site’s survey results for a given year. |
| StatusLUT | Contains a list of Status codes used by combo-boxes in the STATUS form. Assists in keeping records standard. |
| Suggestions | Contains a memo field for database users to record suggestions or observations about the database. Used by the “Suggestions” form. |

**Table SOP 4.2.** NSO monitoring database query descriptions.

| Database Query Name | Description |
|---|---|
| 1IDFINDER | Used by the “idchooser” combo-box on the WELCOME form to query all FormID numbers in the database and order them in descending order to allow the database user to choose which form to print. |
| 2RECORDREVIEW | This is the record source for the “SiteSearchByDate” form. It sorts records by ascending dates for ease of viewing. |
| 3STATUSBYYEAR | This is the record source for the STATUS form. It sorts records by location in ascending order and by year in descending order for ease of viewing in the master database |
| CALLPTSLOCASORTED | This is the record source for the CALLPTSLOCAs form and sorts records by the survey area, year, and station number for ease of viewing. |
| ERRORCHECK ….. | Any query with a title that begins with these letters is a key component of standardized error-checking procedures. ERRORCHECK queries are described in detail in Section 4.0 Data Verification and Validation Procedures. |
| JOINER ….. | Any query that begins with these letters joins tables together in preparation and for use in another query. |
| SUM ….. | Any query which begins with these letters is designed to summarize data. |

**Table SOP 4.3.** NSO monitoring database macro descriptions.

| Database Query Name | Description |
|---|---|
| AutoExec | This macro automatically executes on the opening of the database. It opens the WELCOME form, closes all form toolbars and maximizes the WELCOME form. |
| Close ….. | All macros in the owl database which begin with the word “close” perform commands to close forms when buttons in the associated form called “Close” are clicked. |
| InitialsNew | Forces the Initials form to go to a new record when it is first opened. |
| Open ….. | All macros in the owl database which begin with the word “open” perform commands to open forms when buttons such as those in the header of forms called “All Visits,” “Band Data,” “Nest Info,” or “Status” are clicked. |
| RefreshWelcome | This macro is run when the small button on the right of the idchooser on the WELCOME form is clicked. It closes the WELCOME form and reopens it, forcing the query which generates the list of FormID numbers available to re-run. |
| REVIEW ….. | When macros with this in the title are run, forms will open with records, which need to be error-checked. |

**Table SOP 4.4.** NSO monitoring database form descriptions.

| Database Table Name | Description |
|---|---|
| AboutSSF | This form describes the fields and appropriate entries for the SITESEARCH form. Opened by the “About Site Search Form” at the top left of the SITESEARCH form. |
| AboutSSF2 | A continuation of the “AboutSSF” form. Opened by the “More Descriptions/Definitions” button at the bottom of the “AboutSSF” form. |
| AboutStatus | This form describes the fields and appropriate entries for the STATUS form. Opened by the “About Status Form” button at the top left of the STATUS form. |
| BANDING | Form for the entry of Banding data sheets (not used since termination of banding program in 2003). |
| blanksheets | This form is a menu of options for printing blank forms. |
| CallPointSubForm | Form with the title “Spotted Owl Inventory Call Point Location UTMs” at the top. Data entered into this form are stored in the CALLPTSLOCAs table. |
| CallPtPerformSubform | Used within the SITESEARCH form for the entry of the level of effort performed at inventory call points on a given visit. Data entered into this subform are stored in the CALLPOINTS table. |
| Detection Subform | Used within the SITESEARCH form for the entry of owl and other raptor detections. Data entered here are stored in the DETECTIONS table. |
| Initials | The form in which the names and associated initials of observers can be entered. Data entered into this form are stored in the “InitialsLUT” table. |
| InventoryCallPoints | The form into which inventory call point UTMs can be entered and which appears when the “Enter Point UTMs” button is used on the SITESEARCH form. Data entered into this form are stored in the CALLPTSLOCAs table. |
| MouseSub | This is the subform within the SITESEARCH form into which “Mousing Effort” records can be entered. Data entered into this form are stored in the MICE table. |
| NESTTREES | The form into which the Nest Site Habitat Data field form can be entered. Data entered into this form are stored in the NESTTREES table. |
| PrintBlankInventory | This form is designed to generate a blank inventory form when printed. |
| PrintBlankSiteInvestigation | This form is designed to generate a one-page blank site search form when printed. This form may be used for incidental records and informal surveys |
| PrintBlankSiteSearch | This form is designed to generate a two-page blank site search form when printed. This form may be used for times when surveys are performed by those without ready access to a computer with the database installed. |
| PrintNarrative | This form is designed to print out the narrative of a given record and is only opened from the WELCOME form. |
| PrintSiteInvestigation | This form is designed to print out a one-page version of a given record. It can only be used for site visits during which there was no mousing effort and is only opened from the WELCOME form. |
| PrintSiteSearch | This form is designed to print out a two-page version of a given record. It has enough space for the mousing records and is only opened from the WELCOME form |
| PrintSub | These forms are used by the “PrintBlank” forms to generate empty fields within the detections, mouse, and call point sub-forms. |
| SITESEARCH | The form with the heading “Northern Spotted Owl Site Search Form.” Data entered into this form are stored in the SEARCH table. The form contains master fields (FormID at a minimum) which are automatically entered into child fields in the subforms. Records are ordered by FormID each time the form is opened. |
| RECORDREVIEW | The form with the heading “All Records For One Location.” This is essentially the same form as the SITESEARCH form, but its record source is the query SEARCHBYDATE. The query sorts records by the date field. This form is opened by the button for Site Search Records within the “RECORD REVIEW” section of the WELCOME form, allowing the database user to see all records for one site in |

| Database Table Name | Description |
|---|---|
| | the order of the visits. |
| STATUS | The form with the heading "Site Status and Activity Center." Its record source is the query STATUSBYYEAR and data entered into the form are stored in the table STATUS. |
| Suggestions | A simple form allowing database users to record problems or suggestions in their use of the database. Data entered into this form are stored in the "Suggestions" table. |
| WELCOME | The form with the heading "Marin County Spotted Owl Database" from which the user can navigate to different forms within the database. |

# 2.0 Data Recording and Entry

## 2.1 Data Recording

Data recording procedures are detailed in SOP 2: Standard Field Procedures, including data form examples and database field descriptions (Site Search Form, Nest Habitat Data Form, and Status Form). Primarily, recording is done in the field using a Site Search data form (preferred) or field notebook. Although the observer should complete the site search data form, if time constraints occur, a minimum set of information is required for all field visits: the location or site name, weather, start and end time, a description of the area covered, annotated field map, purpose of survey (e.g., "Purpose of visit is to locate male and determine his band and age" or "Purpose of visit is to confirm reproductive success with second fledgling count"), and results of visit.

A Nest Site Habitat data form should be filled out for each nest found during the season. Although the nest site form can be filled out at any point during the season, observers should consider the nesting activities before embarking on the habitat survey since it can take up to 30 minutes to complete depending on the site.

## 2.2 Additional Spotted Owl Data Files

Additional temporary data files which are useful to program administration, site visit tracking, and site status, should be created annually in either MS Excel or MS Word:

### *2.2.1 Site Visit Table*

This table is used throughout the season to keep track of the progress at each site. The chart will indicate the number of visits performed, the basic outcomes, and the accumulated knowledge about each site.

### *2.2.2 Form ID# Table*

This table is used throughout the season to keep track of the FormID numbers assigned. Having this table will not only avoid duplicating or skipping numbers, but will become an excellent resource at the end of the year for tracking down stray data.

### *2.2.3 Band Tracking Table*

This table is used to keep track of which bands are documented at which sites. This tool will help identify sites which require additional visits in order to read band combinations. Checking owls each visit will also help track if or when a new owl moves into a site.

### *2.2.4 Project Contacts*

This table tracks program contacts including phone numbers and email addresses. Hard copies should be carried into the field at all times.

## 2.3 Data Entry

An electronic Site Search data form is required for all field visits and the electronic entry of the Nest Site Habitat data form is required for each nest with a known location. The blank Site Search data forms can be printed directly from the project database and filled out in the field, but if a field notebook is used, the electronic data form should be entered in the database within a week of the visit. This ensures that the information is still fresh and the observer can provide additional details to their notes, but most importantly it is insurance that if a field notebook is lost, the visit is documented elsewhere.

Per the SFAN Data Management Protocol, several QA/QC procedures must be followed by the database user (Press 2005). The database user must:

- Have a familiarity with the database software, database structure, and any standard codes for data entry that have been developed. Know how to open the data entry form, create a new record, and exit the database properly. Also, learn how to commit both a "field" entry and a complete record entry and correct mistakes made while typing.

- Enter or download data in a timely manner. All data should be entered or downloaded into the project database as soon as possible, preferably no less than once a week.

- Enter the data, one logical "set" at a time. Record in your notebook errors you know you have made or any questions that arise about the data content; these will be useful during data verification. Initial and date each paper form or field notebook entry as it is completed to avoid confusion about what has been entered and what has not with a different color than the data. Interrupt your data entry only at logical stopping points.

# 3.0 Annual Data Work Flow

The master database (NSOMASTERXP.MDB) contains all the site search, nest habitat and banding data collected since 1998. The SFAN Data Manager is responsible for managing the owl database and assisting the project biological technicians with any database issues.

## 3.1 Satellite Databases

Satellite databases are created at the beginning of each season and parallel the structure of the master database. The satellite data tables are blank except for the STATUS, NESTTREES and OWLBAND tables, which should contain the entire available project data collected thus far for reference purposes. The Welcome Form is renamed for the year to help indicate that it is a satellite copy. Satellite databases are provided to GOGA, PORE, and PRBO Conservation Science for use in entering data during the owl field season. The databases are provided in MS Access XP format.

Satellite databases should be backed up regularly during the course of the season. CDs or zip disks are a great option if available. If the database is located on a local area network, regularly copy the database to an archive on the network, on your hard drive, or both. File names of back-up databases should include the date of the back-up, such as:
GOGA_SPOW_2010_Satellite_040110_BackUp

Each team entering data into a satellite database is responsible for proofing their database entry and sending their complete satellite database and hardcopies of all field forms and maps for each site visit to the Lead Biological Technician by August 15$^{th}$ of each season for final review. See Section 4.0 Data Verification and Validation Procedures for more information.

## 3.2 Uploading Annual Data to the Master Database

The SFAN Data Manager incorporates all the satellite databases, including the PRBO database, into a single annual database and completes additional error-checking queries at the end of the season in coordination with the biological technicians. When complete, the Data Manager imports the annual dataset into the master database, appends the data to the appropriate tables, archives the annual dataset, and distributes the updated master database back to PORE, GOGA, and PRBO Conservation Science.

## 3.3 Archiving the Annual Data

Following all error-checking and proofing, all site survey forms are printed, attached to the corresponding field map for each site visit, and placed in a binder for that year. Included in the binder are a hardcopy of the annual report, any larger maps that were printed, and a CD containing a copy of the complete satellite and NSOMASTERXP databases and electronic annual report. Any paper datasheets completed in the field are cataloged in a separate binder. The binders are submitted to the PORE Curatorial Manager two years after the field season to allow for ease of access to field maps by subsequent field staff (e.g., the 2007 data are archived in 2009).

## 3.4 NSO GIS Shapefile

Each year a GIS shapefile of point data is created for all NSO activity centers monitored in all years in Marin County, including the data collected that field season by both the NPS and PRBO. The shapefile includes year, location name, MRN#, occupancy status, reproductive status, and other fields. The attributes are taken from the STATUS table of the monitoring database. A metadata record for the shapefile is created as described in Section 6.0 of this SOP.

### *3.4.1 Creating a GIS Shapefile*

Using the project database (NSOMasterXP.mdb), a make-table query is used to begin records for a new shapefile for all monitoring years. The make-query query transfers fields from the STATUS table into a new database table titled “BIOS REPORT”, which can then be exported in DBF format. In ArcMap (ESRI 2009), select the Add XY Data option under the Tools menu, then navigate to the DBF file containing the BIOS REPORT table fields. In the Add XY Data window, choose UTMEAST for the X field and UTMNORTH for the Y field. Set the coordinate system (Projected Coordinate Systems>UTM>NAD 1983>NAD 1983 UTM Zone 10N.prj), and select OK. The table will now appear as a data source.

To create a new shapefile from the imported table, right click on the SPOW data layer in the display window. Select Data>Export data. In the Saving Data window, keep the default options, select a location for the shapefile, and rename the file (e.g., marin_spow_sites_1999_2009.shp). The shapefile can now be queried for different years, status outcomes, etc.

Use the previous year's XML metadata record and text metadata record to create both metadata records in both formats for the current year's shapefile. Make sure that dates and contact information are up-to-date. The XML file may be edited by using ArcCatalog or the NPS Metadata Tools and Editor.

### 3.5 Annual Report and Data Submission

Once the annual report has been completed, the report is posted to the SFAN website and a record is cataloged in NatureBib. See SOP 5: Data Analysis and Reporting for more information. All project data are also submitted to the Biogeographic Information and Observation System (BIOS) data access system, maintained by the California Department of Fish and Game. Directions for creating the BIOS GIS shapefile and associated metadata records are provided in Section 3.4.1. The annual GIS shapefile and metadata should be copied to the PORE GIS directory for internal NPS use.

## 4.0 Data Verification and Validation Procedures

Ideally two people can participate in the data verification with one person reading the original out loud to another person looking at the computer monitor to verify that the two records match. If only one person is available, they should have any field notes or data forms in front of them.

### 4.1 Site Search Form

#### *4.1.1 Data Verification*

The first step in the process of assuring quality data is to have the recorder re-read the data. This should be done either on the same day that the data were entered or just before beginning new data entry. The field teams should review their data prior to submitting the satellite databases to the Database Manager.

General Procedure:

1) Scan all fields to make sure all have been filled in.
2) Review date field for accuracy.
3) Sort search times in sequential order to make sure they do not contain unlikely values.
4) Ensure that "SPOW Response" matches evidence in the detections.
5) Ensure that the total #s of different ages of owls correspond to the detections.
6) Review the # of mice used and mousing effort for symmetry and logical sequence.
7) Review detections for completeness and correlation with field notes.
8) Review Observational Information check-boxes to ensure the appropriate boxes have been checked.
9) Spell-check the narrative and review for completeness and logic.

### 4.1.2 Form ID Number Sequence Completeness

Before error-checking data, review the Form ID numbers to check for gaps in the sequence. If there is a complete string of numbers for a crew, ensure that the final number is the last number for which there are data. If there is a gap, inquire whether there are data for that number or if it was not used. This process should be done periodically through the season. In some cases, multiple field staff working for the same agency can use different sets of numbers (i.e., 1-100 and 100-200).

At the end of the season, all crews should submit copies of their FormID logs as part of the permanent record. These can be used in future years to compare to existing data sequences.

### 4.1.3 Site Numbers

Run the following query:

> ERRORCHECK10sitenumbers: This query, in conjunction with the ERRORjoinersites query, generates a list of location names which have had different values entered for the MASTEROWL (MRN#) field. If sites are listed when this query is run, then the number in the CountOfMASTEROWL1 field indicates the number of different values in SEARCH records for that site. The correct site number appears next to the Location name.

### 4.1.4 Dates

Open the SEARCH table and promote the date field to ascending order. Review the top dates to see if there are any outliers. Review and correct any dates occurring in the wrong year or in a month outside of the study protocol. Then promote the date field in descending order and review in the same manner.

### 4.1.5 Recorder Initials

Run the following query:

> ERRORCHECK11recorder: This query will display SEARCH table records where there are no matching [RECORDER] initials in the table InitialsLUT. Records will be displayed either because new initials were not added to InitialsLUT or initials were entered incorrectly in the [RECORDER] field. The appropriate additions or corrections should be made.

### 4.1.6 Visit Times

Run the following queries:

> ERRORCHECK26callendtimes: Use this query to generate a list of call end times which occur before call start times. Check narratives and originals and correct.
>
> The visit time ERRORCHECK queries below apply to the visual search start/end time fields, which were part of the survey protocol until 2004 when they were discontinued. Only visit start and end are currently used. These error check queries remain in the database, however, and so are described here as part of the administrative record.

ERRORCHECK27visitstarttimes: Use this query to generate a list of all visit start times which occur after visual search start time. Check narratives and originals and correct.

ERRORCHECK20visualendtimes: Use this query to generate a list of empty “visual search end time” entries where there should be a value entered. Enter the value of the call start time into empty fields. If there was no calling, enter the value of the visit end time field.

ERRORCHECK21visualendtimes: Use this query to generate a list of inappropriate “visual search end time” entries. Running the query will produce a list of records in which the visual search end time was recorded as being after the call start time. Change all visual end times to the value of the call start time. Running the query again should produce an empty table.

ERRORCHECK22visualendtimes: Use this query to generate a list of inappropriate “visual search end time” entries. Running the query will produce a list of records in which the visual search end time was recorded before the visit end time, but during which there was no calling. Change all the “Visitend” values to the values of “Visitend.” Running the query a second time should produce an empty table.

ERRORCHECK23visualendtimes: Use this query to generate a list of remaining inappropriate visual search end time entries. The query generates a list of all visual search end times which do not match either the call start time or the visit end time. Adjust all Visitend fields to match Callstart fields, unless there are any null values in the Callstart field. Use the value in the Visitend field if there is no value in Callstart.

ERRORCHECK24visualendtimes: Use this query to generate a list of detections where there was no calling, but in which the visual end time and the detection time are the same. Check the narrative of the record and verify that the record is accurate.

ERRORCHECK25visualendtimes: Use this query to generate a list of visual search end times that were recorded as times that occurred before or equal to the visual search start times. The call start time is listed for reference. For records where visual search start and end and call start times are all the same, erase the times entered in visual search times, since there was no visual search. For records where the time of visual search end time occurred before visual search end time, review the narrative and original of the record for the correct time.

### 4.1.7 Visit Summary

Run the following queries:

ERRORCHECK30formalsurvey: This query generates a list of all visits for which "No" was the response to the "Formal Survey?" question. Review these records to assure that this was the correct response.

ERRORCHECK31spowresponse: This query will generate a list of records for which "No" was recorded in the Visit Summary to the "SPOW Response?" question, but for which there was a detection recorded. Check any records listed to assure that the detection is meant to be associated with the visit and change the SPOWRESPONSE field appropriately.

ERRORCHECK32otherowls: This query generates a list of records for which the visit summary indicates that no other owls were seen, but for which there exists a non-SPOW detection record. Review the listed site visits and make corrections if needed.

ERRORCHECK33nestlings: This query will generate a list of records for which the visit summary indicates that there were a different number of nestlings than the number of nestling detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK34branchers: This query will generate a list of records for which the visit summary indicates that there were a different number of branchers than the number of brancher detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK35fledglings: This query will generate a list of records for which the visit summary indicates that there were a different number of fledglings than the number of fledgling detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK36mature: This query will generate a list of records when an entry for the visit summary's "mature SPOW" field is different from the number of entries in the "Owl Detections" field (for adult and subadult SPOW). Review the record(s) and make appropriate changes.

ERRORCHECK37viewofnest: This query generates a list of records for which the recorder stated that there was an adequate view into the nest to see all owls that were present within it, but for which no young were recorded, no female was stated to have been on the nest, and the record does not indicate that the site is non-reproducing or a confirmed nest failure. If you discover many records generated from this query, run the "REVIEWviewofnest" macro to review all of them in form view. Review the records and change whichever field is inaccurate. NOTE: This field did not exist prior to 2000 data.

ERRORCHECK38mice: This query will generate a list of records for which the recorder stated that there was no mousing, but for which 1 or more mice were used.

ERRORCHECK39mice: This query generates a list of records in which the field for "Total #Mice Used:" does not match the number of records of mice which were taken. The query works in conjunction with the two queries with "ERRORjoinermice" in the titles.

### 4.1.8 Indicate Completion

Once all of the above queries have been run and all fields in the visit summary fields have been error-checked, ensure that the "ErrorVisitSumChecked" and "ErrorMouseChecked" checkboxes in the SEARCH table are checked, or set to True. Alternatively, one can check the "Summary Checked" and "Mice Checked" boxes in the related Site Search Form.

## 4.2 Detections Form

### *4.2.1 Band Resightings*

Partial band color observations do not count as a band color, but should rather be noted as "PRESENT". For example, if you see orange on a band but are not certain of the absence or presence of a pattern, record "orange" only in your notes and in the narrative and "PRESENT" in the data field "band color."

Check for standard use of field terms: while checking all band records, make certain that the following terms are used appropriately:

> PRESENT: used when a band was known to be present, but the color is not known. For example, if observer recorded a color for a tab, but nothing for band color, record "present" as band color.
>
> NONE: used only when it was verified that no band was present on the owl. Both legs must be seen. If such records are found at sites where owls of that sex were already banded, make certain from the field notes that the observer verified the absence of bands on the owl.
>
> UNKNOWN: used in all situations where both legs could not be seen or the observer failed to record the color of a band or whether bands were looked at.
>
> GONE: This value should be used for tabs which have been removed by the owls wearing them.

Error-Check**:** Several steps will be required to complete error-checking. Check the "Bands Checked" box in the Site Search form or the "ErrorBandsChecked" field directly in the SEARCH table only when all steps have been completed.

Run the following queries:

> ERRORCHECK0referencebands: This query generates a list of all the band colors of owls banded in the study area. The query may be printed and used for reference in other error-checking queries.
>
> ERRORCHECK40nonspowbands: This query generates a list of all non-NSO detections for which a band color was recorded. Check to see if this unusual event actually happened.
>
> ERRORCHECK41nullbandvalues: This query will generate a list of all NSO detections for which no information was recorded for band colors. Review all of the records to assure that the appropriate value is "UNKNOWN" and change accordingly.
>
> ERRORCHECK42owlsthatmoved: This query will generate a list of all NSO band combinations which were given (banded) at one location and then recorded as observed at another location. Check the narratives and other records to verify, make appropriate changes,

then print up the remaining verified relocated owl records and use for reference during next queries.

ERRORCHECK43ifybands: This query generates a list of questionable band colors. Review to make sure that these represent owls that moved or for which there was a justifiably unknown "Band leg" value recorded. Change partial colors, e.g., "green" for "green white triangle" to "PRESENT." Only true values of band colors should be entered in the band color field. This query runs in conjunction to the ERRORjoinerBcolors and ERRORjoinerBdetecombos queries.

ERRORCHECK44ifyband+tabs: This query will generate a list of sex/band/tab/leg combinations that were recorded for detections which do not exist in the banding records. Some records should include the owls that have removed their tabs. Check these and all others to verify accuracy and make appropriate changes if possible. This query works with the ERRORjoinerBcombos query and the ERRORjoinerBdetecombos2 query.

ERRORCHECK45bandedleg: Run this query to generate a list of all records for which the recorder stated that there were no bands on the owl (NONE as color) but for which they recorded a leg. Because “NONE” is meant to indicate that there were no bands on either leg of the owl, review the records that show up and change the band color to “UNKNOWN” and the leg to U if the narrative indicates that only one leg was seen. If the narrative indicates that both legs were seen, change the leg field to “N” to represent that neither leg bore a band.

ERRORCHECK45bandedleg2: Run this query to generate a list of all records for which the recorder stated that the band color was UNKNOWN, but for which they specified a leg. Review the records to see if this was meant to indicate that no colored band was seen on the other leg, but that this leg remained unknown.

ERRORCHECK45bandedleg3: Run this query to generate a list of all records for which the recorder stated “PRESENT” as the band color and for which they indicated a leg. Review to make sure that the narrative indicates that the band was known to be on that leg.

### *4.2.2 UTMs*

Before reviewing the UTMs for accuracy, the dataset must be complete. Open the DETECTIONS table and sort the UTM_EAST field ascending. Null values should appear on top. Record the FormID numbers, location and dates and review the original maps to generate UTMs. Repeat for the UTM_NORTH field.

The first step in reviewing the UTMs is to correct those which erroneously fall outside of Marin County by running the ERRORCHECK51utmeast and ERRORCHECK52utmsnorth queries. Check the original maps and correct.

Use the query ERRORCHECK53utms to create a GIS event theme of NSO detections by completing the following steps:

1. Temporarily change the ERRORCHECK53utms query to a make-table query and run the query to create a new table.

2. Open ArcMap and begin a new empty map.

3. Select the Add XY Data option under the Tools menu, navigate to the NSOMASTER database and select the temporary table you just created.

4. In the Add XY Data window, choose UTM_EAST for the X field and UTM_NORTH for the Y field.

5. Set the coordinate system (Projected Coordinate Systems>UTM>NAD 1983>NAD 1983 UTM Zone 10N.prj ), and select OK. The table will now appear as a data source in the map.

For comparison, add the previous year's shapefile to the map (see Section 3.4). Loading the current year of data and the shapefile of the previous year's activity site centers, one can visually see what lies at unusual distances from the activity center. These detections should be reviewed against the original field maps for accuracy. While zoomed out to the extent of the study area, scan the map to look for unusually large clusters. Zoom into these and use the identify feature to look for mismatched site names. Measure the distance between distant points bearing the same site name. Verify that anything over 250 m apart is appropriate.

To identify outliers within each activity site, perform an auto-label by site name to all the points while zoomed in fairly closely. Contrary names which overlap in the same activity area need to be examined to see which were incorrectly entered.

When complete, be sure to delete the temporary table used to create the GIS theme from the database. Check the "UTMs Checked" box in the Site Search form or the "ErrorUTMsChecked" field directly in the SEARCH table only when all steps have been completed.

### 4.3 Status Form

The status form is the last form to be completed for each site each year and summarizes the survey results for each site. Complete descriptions of each status level (occupancy, residency, pair status, nesting status, and reproductive status) and descriptions of determinations are found in SOP 3: Status Designations. Directions for entering data into status form fields and available values are described in detail in SOP 3.

Due to the complexities of the survey protocol, nothing can replace repeated review of the Site Search records in comparison to the STATUS table for accuracy. However, some queries have been built to locate potential errors. These procedures are not comprehensive however, and it is recommended that the entire set of STATUS records are reviewed at least three times, reviewing each field against supporting evidence. See SOP 2: Standard Field Procedures for details on field descriptions as well as the database help text available from the STATUS form. Run the following queries to verify that the status entered in the STATUS form has evidence supporting it in the site search records. When error checking is complete, select the “Error Checked” box in the STATUS form for all records.

ERRORCHECK71statusNY: This query generates a list of all sites which were designated as Nested with Young (NY) produced, but for which there are no SEARCH records which have detections of branchers or fledglings.

ERRORCHECK72statusNF: This query generates a list of all sites which were designated as a Nest Failure (NF), but for which there are no associated SEARCH records with the NONNESTINGINDICATORS field. The field represents surveys in which mice were taken, but were not brought to the young. Review to make sure that the nest failures listed in this query were confirmed by adequate follow-up visits to visible nests after initial nesting confirmation.

ERRORCHECK73statusN: This query generates a list of STATUS records which were not designated Nested with Young (NY), but for which there was a fledgling record. Review and make appropriate changes.

ERRORCHECKstatusNN+: This query generates a list of STATUS records with Non-Nesting (NN) or Unknown (UK) Nesting status codes, but for which there is a positive response in the SEARCH records to the NESTINGINDICATORS field.

Additional error-checking queries such as these can be added to the database to more comprehensively check for likely problems.

To check the UTMs in the STATUS table for accuracy, view the table as a GIS event theme in a new ArcMap project following the directions given in Section 4.2(b) for checking the accuracy of UTMs in the DETECTIONS table. Add the theme of the preceding year's shapefile. Set unique symbols for the two different layers to compare the locations and look for large movements or incorrect UTMs. Review all UTMs which emerged in unlikely or suspiciously far points. Correct any UTMs that need correcting in the database.

Reminder: Do not edit the table in the previous year's shapefile because the changes will be made to the associated DBF file immediately.

### 4.4 Nest Tree Habitat Form

Error-check all of the Nest Tree Habitat forms by reading the original physical datasheet and comparing this to the data that was entered into the database. Correct any mistakes and check the "Error Checked" box on the form. See SOP 2: Standard Field Procedures for detailed description of data form/database fields.

## 5.0 Version Control Guidelines and Database History

Version control guidelines for the MS Access Northern Spotted Owl Monitoring Database will follow those presented in the SFAN’s Data Management Plan (Press 2005). Prior to any major changes to the database design, a back-up copy of the database should be made. Once the database design changes are complete, the database should be assigned the next incremental version number. The final copy of the previous database version should be archived with the version closing date incorporated into the database title. Version numbers should increase incrementally by hundredths (e.g., version 1_01, version 1_02, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2_0, 3_0, 4_0 …). With proper controls and communication, versioning ensures that only the most current database version is used for queries and analyses. Significant database re-design may require approval by the project manager, review by other data management staff, and revisions to this data management SOP. The database version number should be included in the file title of the database, for example, NSOMASTERXP_v1_00.

The SFAN Data Manager maintains a history of the Northern Spotted Owl Monitoring Database in a MS Word document titled *NSOMASTER_Database_History* located at:

Inppore04\Resources\Natural_Databases\Spotted Owl

All design modifications to the database are tracked within this document and are referenced to changes in database version numbers. Major changes to the data themselves are also noted in this document, such as when a new set of annual data is uploaded. It is especially important to note edits to the data that will result in changes to final data summaries previously published in annual reports or other media. This will prove invaluable to data users attempting to understand differences in data between years.

The database history may also be used each year to summarize anything that was unique or changed about the year's methodology and is therefore reflected in the annual dataset. Notes on techniques for collection and review of data are also very helpful.

Data related administrative records previously stored within the database in the YEARMetainfo table have been transferred to the *NSOMASTER_Database_History* document.

## 6.0 Metadata Procedures

The NPS GIS Committee recently required all NPS GIS data layers be described with the NPS Metadata Profile, which combines the FDGC standard, elements of the ESRI metadata profile, the Biological Data Profile, and NPS-specific elements. Although no standard has been applied to natural resource databases and spreadsheets, the SFAN completed the NPS Metadata Profile to the greatest extent possible to document the master MS Access NSO Monitoring Database.

The metadata record for the Northern Spotted Owl Monitoring Database was initially developed in Dataset Catalog v3.0, an MS Access metadata development and catalog tool developed by the NPS I&M Program. Dataset Catalog is currently the preferred tool to begin metadata records for MS Access databases because of its ability to harvest entity and attribute information from this database format.

The metadata record was exported from Dataset Catalog as an XML file and completed in NPS Metadata Tools and Editor v1.1 (NPS MTE), thus allowing for all NPS-specific elements in the metadata record to be completed. When completed, the metadata record, but not the data themselves, was posted to the NPS Data Store for public discovery and consumption. The database, and any GIS data resulting from the monitoring program, is considered sensitive information and is not available publicly, but distributed through data requests to the Data Manager. Contact information within the metadata record directs interested parties to the SFAN Data Manager for further inquiries. The metadata record posted to the NPS Data Store will be updated annually after the annual data have been uploaded or following database revision to a new version whole number (i.e., v1_3 to v2_0, but not v2_0 to v2_1).

The location data for this project are stored as UTM coordinates within the MS Access master database. Because GIS spatial data layers are generated from the database for internal use only, only simplified metadata records will be developed for these data layers using ArcCatalog and the NPS MTE. The metadata records will be saved as XML files and should be stored with the spatial data files, but not posted to the NPS Data Store.

At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. A complete and thorough metadata record for the BIOS submission has been created in ArcCatalog and the NPS MTE and may simply be updated annually prior to submission. See SOP 5: Data Analysis and Reporting for detailed instructions.

The complete protocol for this project is an integral component of the project metadata. All narrative and SOP version changes are noted in the Master Version Table (MVT), which is maintained in SOP 7: Revising the Protocol. Any time the narrative or SOP versions are changed, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be properly interpreted and analyzed. The protocol narrative, SOPs, and data should not be distributed independently of this table.

## 7.0 Data Storage

NPS IT specialists keep servers at both PORE and GOGA locked and secure, perform regular server maintenance and upgrades, and ensure that frequent server back-up procedures are functioning properly with weekly off-site storage.

All master data files for the NSO monitoring project are housed at PORE. NSOMASTERXP, the master database, currently in version 1_0, resides at:

Inppore04\Resources\Natural_Databases\Spotted Owl

Inppore04\Resources must always be mapped as the U drive. The following folders reside within the above directory:

**SPOW_BackUps**
Back-up copies of the master database or of annual satellite databases should be stored here. File names of back-up databases should include the date of the back-up, such as: NSOMASTERXP_v1_00_040110_BackUp.

**Archived_Master_Dbase_Versions**
When the master database is converted to a new version number, the final previous database version should be archived here.

**Archived Annual Data**
Separate folders for each year (i.e., Archived 2009 Data) store final satellite databases and other final annual data products.

**BIOS Submission**
Separate folders for each year (i.e., BIOS Submission 2009) store correspondence and final data products submitted to the BIOS data access system.

**GIS Files**
GIS files are housed on a separate server at:

Inppore07\GIS\vector1\wildlife\spottedowl\covers

Inppore07\GIS must always be mapped to the S drive.

**Documents**
Protocol documents, annual reports, seasonal documents or temporary data files (see Section 2.2), and all other project related files are located at:

Inppore04\Resources\Science\Spotted Owls

At the SFAN offices at GOGA, copies of all final documents and data relating to the spotted owl monitoring program are archived at:

Inpgogamahe1\Divisons\Network I&M\IM_Archive\VS_Indicators\Spotted_Owl

Data and documents are stored in separate folders. The master database will be copied and archived here annually after that year's field data have been error-checked and uploaded. All final documents relating to the NSO monitoring program, including the protocol and all annual reports, will also be stored in the NSO archive directory. All files in the archive directory are stored in read-only format.

# 8.0 Literature Cited

ESRI (Environmental Science Research Institute, Inc.). 2009. ArcGIS 9.3.1. ESRI, Redlands, CA.

Press, D.T. 2005. Data management plan for the San Francisco Bay Area Network inventory and monitoring program. USDI National Park Service. San Francisco, CA. 113 pp.

# SOP 5. Data Analysis and Reporting
*Version 1.3*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| 1.0 | Nov. 2007 | Dawn Adams | Reformatted | To meet new formatting guidelines. | 1.1 |
| 1.1 | March 2008 | Dawn Adams, Dave Press, Marcus Koenen, Bill Merkle | Updating analysis section | New analysis | 1.2 |
| 1.2 | March 2010 | D. Press, L.A. Starcevich | Significant expansion of section on long-term analytical techniques and reporting. Added Literature Cited section. Added two appendices. | New analytical methods. Response to peer review comments. | 1.3 |

# Contents

## Figures



## Tables



## Appendices

This SOP details the formal reports (e.g., annual reports) and informal reports (e.g., web updates) produced through the I&M Program. For each report, content is described and analyses are presented. Additional information on analyses is also presented in SOP 4: Data Management Handbook.

# 1.0 Annual and Long-Term Trend Reports

This section provides instructions for: 1) annual data analysis and reports, and 2) periodic trend analysis and reporting for northern spotted owl (NSO) monitoring in the San Francisco Bay Area Network (SFAN). For the annual reports and long-term trend analysis, only NPS occupancy and fecundity data collected within the NSO study area are analyzed and presented. The exception is the nesting habitat and nest structures section of the annual report, which includes data gathered on all nests located in the county since 1998.

## 1.1 Annual Reports

The purpose of the annual report is to summarize the data for the current year, as well as to provide for some comparison with data from previous years. The report is prepared by the Lead Biological Technician and reviewed by the project staff from Point Reyes National Seashore (PORE) and Golden Gate National Recreation Area (GOGA). The first draft of the report is produced in the late-summer or fall following the field season once the data has all been error-checked. Peer-review and completion of the report are the responsibilities of the NSO program managers and should be finalized before the start of the next field season. The report summarizes occupancy, fecundity, and any other relevant information. The 2008 annual report, which went through a formal peer review process, will serve as a template for future annual reports.

### *1.1.1 Data Summaries*

In each annual report, statistics are presented for the following standard survey parameters at a minimum:

- Site occupancy
    - Number and percentage of occupied territories*
    - Occupancy status summary (number of single, pair, unoccupied sites)*
- Reproduction
    - Reproductive status summary (number of nesting and non-nesting pairs, number of nest failures, number of nests that fledged young, and number of young)*
    - Fecundity (average number of female young per territorial female with standard error)*
    - Productivity (average number of young per occupied territory with standard error)*
- Age composition of pairs*
- Survey effort (mean and range of number of visits per site)
- Nest tree measurements
    - Nest type, height, and aspect
    - Nest tree species, height, and diameter at breast height
- Habitat characteristics (presented as average for the season)
    - Dominant understory and overstory vegetation types (general description)
    - Elevation*

- Slope*
- Slope position
- Distance to forest opening*
- Distance to forest edge*
- Distance to water*

- Weather metrics from Mt. Barnabe and/or Bear Valley weather stations
  - Average monthly precipitation*
  - Monthly wind speed (number of days per month with high wind speed of 20 mph or higher)*

* Values with asterisk are also presented in a report figure to help visualize trends.

Incidental data collected is also reported, including:

- Barred owl statistics
  - Number of detections
  - Number of NSO sites with barred owls detected
  - Barred owl occupancy status at sites
  - Estimate of number of barred owls in study area
- Medium to large scale changes in NSO habitat (e.g., wildfires)

Report figures are formatted in a MS Excel spreadsheet and can be updated with current year values and inserted into the report.

An example table summarizing annual monitoring results is shown in Table SOP 5.1. Site occupancy and reproductive status are also reported as percentages of different occupancy (Figure SOP 5.1) and reproductive status classes (Figure SOP 5.2) for comparison with other monitoring years. Annual population fecundity is determined by calculating an average fecundity of territorial females within the monitored sample. Fecundity is the number of female young (# of fledglings/2) per territorial female (Franklin et al. 1996). Standard error of the sample is also reported.

The annual reports generally do not contain sensitive owl information and, therefore, can be distributed to the public. Any maps created are done in large scale and without specific landscape details and no owl locations are mentioned by name in the report.

**Table SOP 5.1.** Summary of the spotted owl monitoring results for the 2008 breeding season.

| Number of sites monitored | Number of occupied territories | Number of sites occupied by pairs | Number of sites with known reproductive outcomes | Number of nests located | Number of young produced | Fecundity |
|---|---|---|---|---|---|---|
| 25 | 20 | 15 | 13 | 6 | 18 | 0.69 |

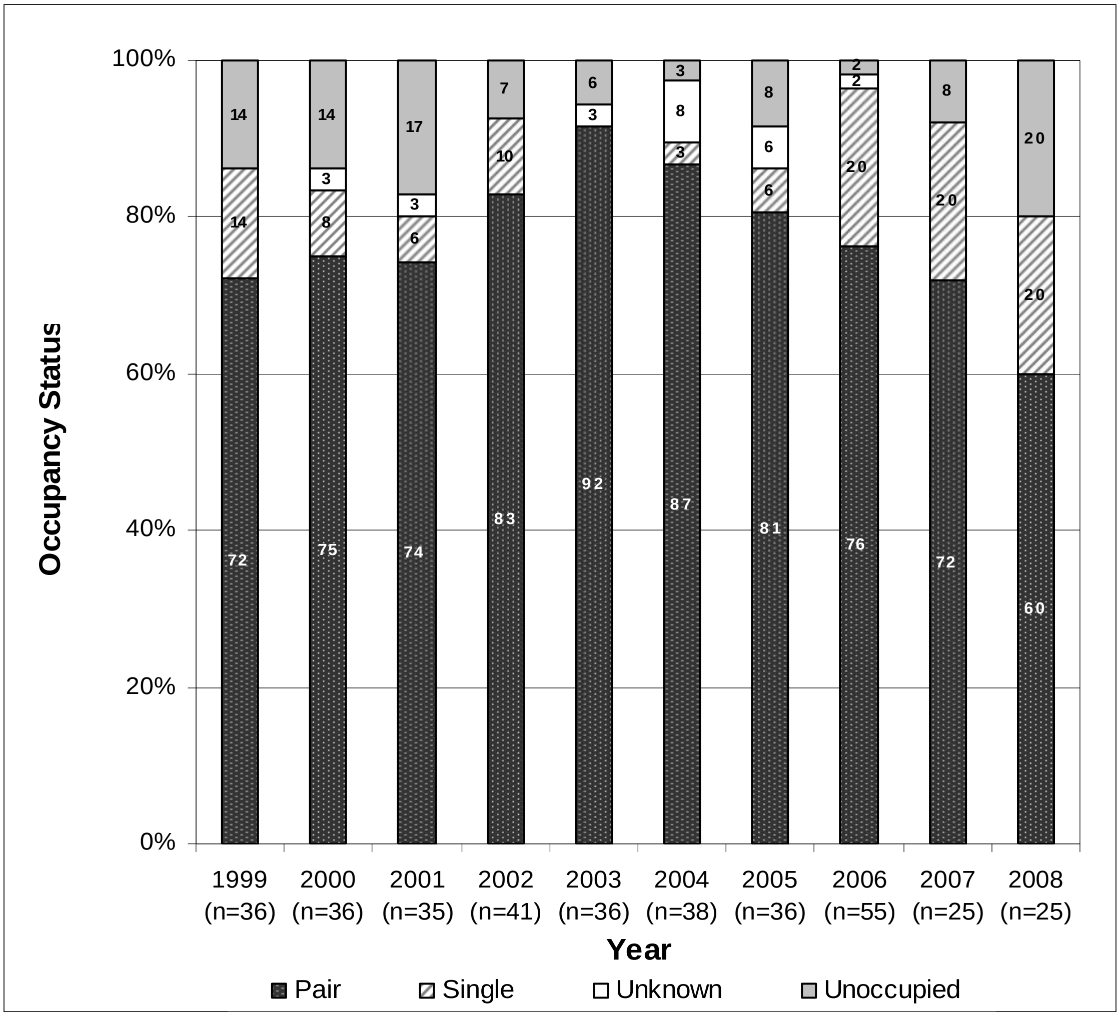


**Figure SOP 5.1.** Occupancy status for all NPS study sites (1999-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories.

## 1.2 Long-Term Trend Reports

Every 5 years, the program will develop a larger trend analysis and protocol review. Long-term trend reports would be produced by the project leads and other network staff or through cooperative agreements or contracts depending on funding availability. The focus of the trend assessments will be on the key parameters in the study design, specifically territory occupancy rate and fecundity. The report will include examining patterns and trends in nesting habitat selection. At that time, additional factors will be considered for analysis, especially as they relate to NSO occupancy and fecundity. Some examples of potential analyses are examining differences in occupancy and fecundity rates between age classes of females and males, factors associated with differences in habitat quality, different nesting habitat factors (e.g., distance to water, forest edge, and dominant forest structure). A long-term trend assessment is also an appropriate point to analyze the effects of climate and weather conditions, the presence of barred owls, and the presence and severity of Sudden Oak Death (SOD). The significance of these

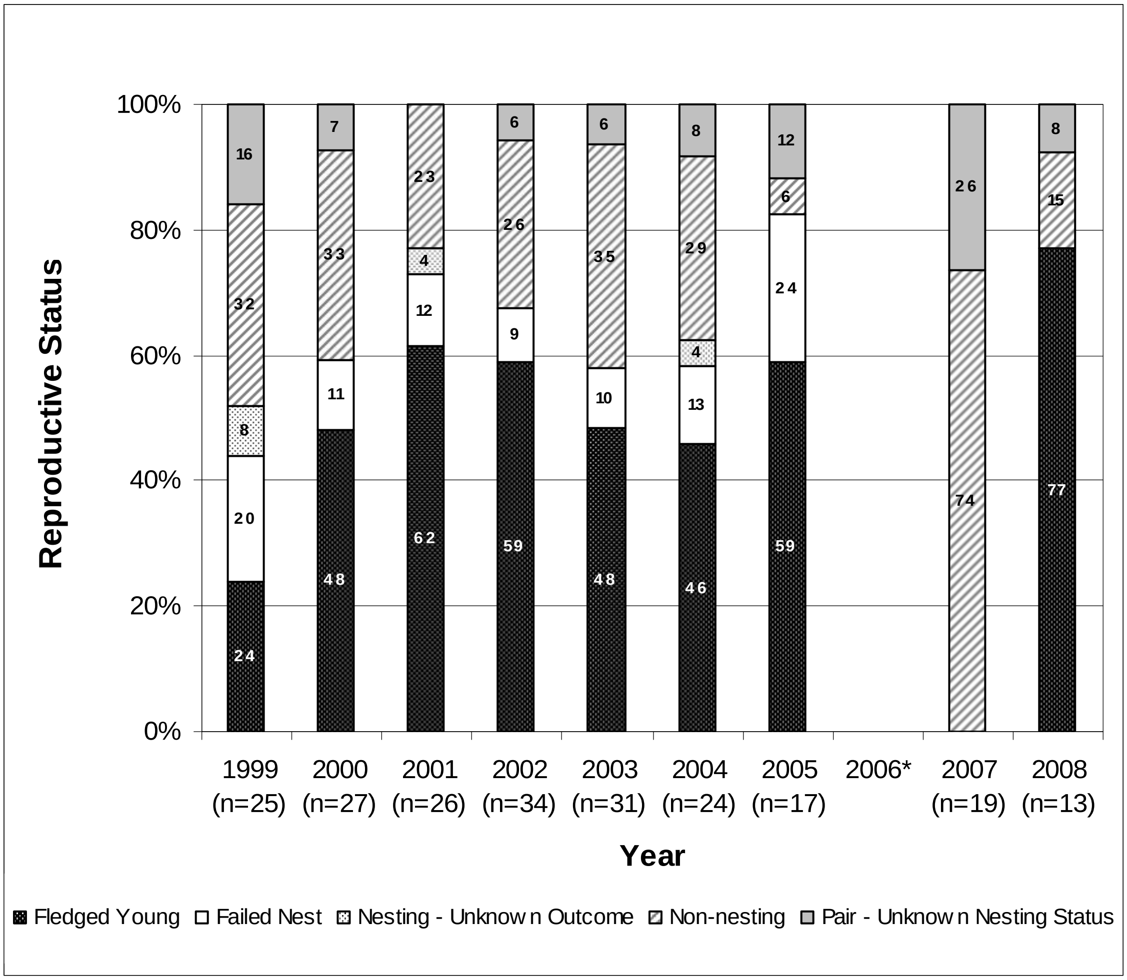


**Figure SOP 5.2.** Reproductive status for owl pairs monitored in the NPS study area (1999-2005 and 2007-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories. *2006 inventory data was excluded from this analysis.

effects may be assessed with likelihood ratio tests of regression coefficients in the models for occupancy, fecundity, or detection rates. Results will be discussed within the context of the Marin County NSO population, by including data collected on MMWD and MCOSD lands, and within a regional context, by comparing NSO trends in other parts of California.

### *1.2.1 Occupancy Analysis*

Methods for detecting long-term trends in the NSO occupancy data were developed by Starcevich and Steinhorst (2010; Appendix A), which used 10 years of NPS NSO monitoring data to estimate the power to detect trends in preparation for this protocol. The methods in Starcevich and Steinhorst (2010) will serve as a roadmap for future long-term trend analyses and are summarized here. Our statistical approach may evolve over time allowing us to include new covariates into the analysis, such as climatic factors or SOD, and to keep up to date with the latest analytical techniques.

Analysis code for estimating trends in occupancy rate is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. Instructions are given to conduct the occupancy and fecundity trend analysis with the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

The spotted owl monitoring program employs six mutually exclusive northern spotted owl site occupancy categories (Table SOP 5.2). Occupancy will be estimated independently for each category.

**Table SOP 5.2.** Northern spotted owl occupancy categories.

| Occupancy Code | Description |
|---|---|
| PR | Resident pair detected |
| PU | Pair detected but pair occupancy not confirmed |
| RS | Resident single |
| SU | Single detected but occupancy not confirmed |
| UK | Occupancy status unknown |
| UO | Unoccupied |

When more than three years of monitoring data are available, linear trends in the logged odds of occupancy may be estimated and tested for significance. The number of detections is modeled as a zero-inflated binomial random variable (MacKenzie et al. 2006). Let $y_{ijk}$ be the outcome for site $i$, year $j$, and visit $k$, and let $y_{ijk}$ take a value of 1 if a spotted owl is detected and 0 otherwise. Since the outcome is either 0 or 1, the outcome actually has a zero-inflated Bernoulli distribution. Let $y_{ijk}$ be the number of detections made at site $i$ and year $j$ during the $k^{th}$ visit. The zero-inflated Bernoulli distribution is expressed as:

$$P\left(Y = y_{ijk}\right) = \pi_{ij} p_{ij}^{\ y_{ijk}} \left(1 - p_{ij}\right)^{1-y_{ijk}} + \left(1-\pi_{ij}\right) I\left(y_{ij} = 0\right),$$

where $\pi_{ij}$ is the occupancy rate in site $i$ and year $j$, and $p_{ij}$ is the detection rate for site $i$ and year $j$. There are $S$ sites; $T$ years, and $K$ visits to a site each year. Define the indicator function as $I\left(y_{ij} = 0\right)$ as 1 when $y_{ij} = 0$ and 0 otherwise. This model assumes an equal number of visits to a site within a year, but $K$ can vary among sites and/or years.

Occupancy ($\pi$) is modeled with logistic regression as a function of related covariates:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \gamma_0 + \gamma_1 x_{ij}.$$

To test for linear trend in the logged odds of occupancy, the year covariate, $x_j$, should be included as a predictor in the occupancy model. The likelihood ratio test is used to assess the significance of the trend coefficient.

The probability of zero inflation (p) is simultaneously estimated by logistic regression:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right)=\beta_0+\beta'_1 x_{ij}\,.$$

Maximum likelihood is used to estimate the parameter values from the models for occupancy and detection rates and the zero-inflated Bernouilli distribution. Occupancy can be modeled at the site-by-year level so predictors should be collected at the site level, year level, or site-by-year level. Detection probabilities are allowed to vary at each visit for each site and year, so covariates are often environmental covariates that vary from visit to visit (MacKenzie et al. 2006). However, if detection rates are also changing over time, a model that includes a year covariate may be needed for accurate occupancy estimation.

The implicit occupancy model is assumed for this analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

Model selection is conducted using the Akaike Information Criterion (AIC). Model output is examined to be certain that valid variance estimates are obtained. When valid estimates of the variance cannot be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance is used.

For the pilot data, the occupancy model selected by AIC included site-level, year-level, and visit-level covariates (Table SOP 5.3). Possible detection models were based on covariates collected within each site and year such as month, an indicator for a day vs. night survey, an indicator for whether a call method was used, and the number of observers. The detection model with the lowest AIC for the NSO pilot data collected from 1999 to 2008 includes the indicator for day survey, the indicator for call use, and the number of observers.

**Table SOP 5.3.** Covariate information available for occupancy and detection modeling (Starcevich and Steinhorst 2010).

| Covariate Code | Level | Description |
|---|---|---|
| Year | Year | Year of the survey |
| Month | Visit | Month of the survey |
| Barred | Site | Indicator of barred owl detection at a site for a given year |
| Daytime | Visit | Indicator that survey occurred during the day |
| Call | Visit | Indicator that a call method was used |
| ObsNum | Visit | Number of observers present during the survey |

The process of model selection was problematic for the spotted owl pilot data. Because occupancy analysis is based on a nonlinear model, obtaining a positive-definite Hessian matrix was not possible for some models. The Hessian matrix affects the estimates of variance for occupancy and detection regression parameter estimates which affects trend testing. Model selection was conducted using AIC as the model selection criterion (Bayes Information Criterion was also examined but selected similar models). However, models chosen with AIC often did not provide positive-definite Hessian matrices. The model with the lowest AIC and a positive-definite Hessian matrix was used in the power analysis for trend testing. The final occupancy and detection models are provided for each status category in Table SOP 5.4. The final models were often a reduced version of the model with the lowest AIC indicating that simpler models are more stable for occupancy estimation. The occupancy estimates by category are provided in Table SOP 5.5.

**Table SOP 5.4.** Final occupancy and detection models for each spotted owl occupancy category (Starcevich and Steinhorst 2010).

| Status Category | Occupancy Model $\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)$ | Detection Model $\log\left(\frac{p_{ij}}{1-p_{ij}}\right)$ |
|---|---|---|
| PR | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij} + \beta_3 \text{ObsNum}_{ij}$ |
| PU | $\gamma_0$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| RS | $\gamma_0$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| SU | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| UK | $\gamma_0$ | $\beta_0 + \beta_1 \text{Month}_{ij} + \beta_2 \text{Call}_{ij}$ |
| UO | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Call}_{ij}$ |

**Table SOP 5.5.** Occupancy estimates (and standard errors) from the final model for each spotted owl occupancy category (Starcevich and Steinhorst 2010).

| Status Category | Est. Occupancy Rate for Sites with Barred Owls (SE) | Est. Occupancy Rate for Sites without Barred Owls (SE) | Est. Occupancy Rate (SE) |
|---|---|---|---|
| PR | 0.9197 (0.0505) | ~ 1.000 (0.00001) | - |
| PU | - | - | 0.0301 (0.0146) |
| RS | - | - | 0.1614 (0.0428) |
| SU | 0.2562 (0.0960) | 0.1127 (0.0384) | - |
| UK | - | - | 0.0208 (0.0058) |
| UO | 0.1172 (0.0371) | 0.0601 (0.0124) | - |

Analysis code using the R software package is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. For each status category, occupancy estimates are provided either for the model including the indicator of barred owl presence (estimates of occupancy with and without barred owl presence are provided in the second and third columns) or the model without a factor for barred owl presence (occupancy estimates given in the fourth column).

Columns for the unused model contain a "-" to indicate that this model was not used. Due to the complexities of estimating trend with a multi-category occupancy classification, a univariate approach was used and occupancy estimates do not sum to 1. Notice that the presence of barred owls in a site and year decreases pair occupancy but increases the single-unknown and unoccupied status categories. This result suggests that the effect of barred owl presence is to reduce pair occupancy and inhibit territorial behavior as evidenced by the positive effects observed in the SU and UK status categories.

### *1.2.2 Fecundity Analysis*

Methods for detecting long-term trends in the NSO fecundity data were developed by Starcevich and Steinhorst (2010; Appendix A; Appendix SOP 5A), which used 10 years of NPS NSO monitoring data to analyze re-visit designs and to estimate the power to detect trends in preparation for this protocol. The methods in Starcevich and Steinhorst (2010) will serve as a roadmap for future long-term trend analyses and are summarized here. Our statistical approach may evolve over time allowing us to include new covariates into the analysis, such as barred owl presence or SOD, and to keep up to date with the latest analytical techniques.

Analysis code for estimating and testing trends in fecundity rates is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. Instructions are given for the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

Let $y_{ij}$ be the number of fledglings per territorial female detected in occupied site *i* and year *j*. Let *n* be the number of occupied sites and *T* be the number of years monitored for fecundity. The probability mass function of *Y* is:

$$P\left(Y = y_{ij}\right) = \pi_j \binom{M}{y_{ij}} p_{ij}^{\,y_{ij}} \left(1 - p_{ij}\right)^{M - y_{ij}} + \left(1 - \pi_j\right) I\left(y_{ij} = 0\right),$$

where $\pi_j$ is the probability that an extra 0 is **not** observed at site *i* in year *j*, $p_{ij}$ is the probability of a fledgling at site *i* in year *j*, *M* is the maximum number of fledglings seen in any nest, and $I(y_{ij} = 0)$ is 1 when $y_{ij} = 0$ and is 0 otherwise. Similarly to the occupancy analysis, the parameters, $\pi_{ij}$ and $p_{ij}$, are estimated with maximum likelihood estimation. To test for trend in fecundity, the year covariate is included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change in $p_{ij}$ over time. We assume that *M* is 5 based on historical data and recommendations from the SFAN ecologists.

Fecundity of spotted owls is measured by the number of fledglings per territorial female. Nesting spotted owls can produce 0 to 3 fledglings, though a maximum of two fledglings was observed from the pilot data. The 1998-2008 pilot data indicate that zero inflation may be an issue (Figure SOP 5.3). Zero inflation may result from a high number of non-nesting pairs or nest failures related to predation or environmental factors.

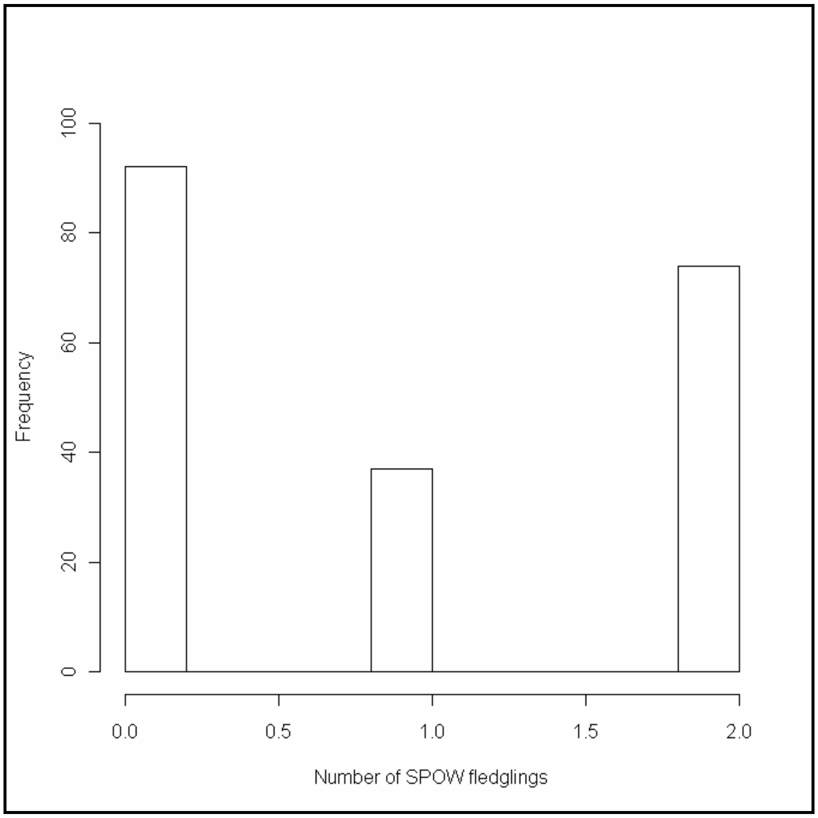


**Figure SOP 5.3.** Histogram of spotted owl fledglings across years, 1998-2008.

Fecundity is measured as the binomial probability for fledglings. These estimates are provided in Table 5.6 by year. While the estimates indicate an increasing trend (Figure SOP 5.4), the increase is not significant (LRT test statistic: 0.0043, p-value: 0.9479). The probability of not detecting an extra zero is estimated as 0.6396 (SE 0.0466).

**Table SOP 5.6.** Estimated binomial probabilities for fledgling.

| Year | Estimated Binomial Probability for Fledglings (SE) |
|---|---|
| 1999 | 0.4715 (0.0686) |
| 2000 | 0.4724 (0.0574) |
| 2001 | 0.4732 (0.0473) |
| 2002 | 0.4741 (0.0393) |
| 2003 | 0.4750 (0.0349) |
| 2004 | 0.4758 (0.0353) |
| 2005 | 0.4767 (0.0405) |
| 2006 | 0.4776 (0.0490) |
| 2007 | 0.4784 (0.0593) |
| 2008 | 0.4793 (0.0707) |

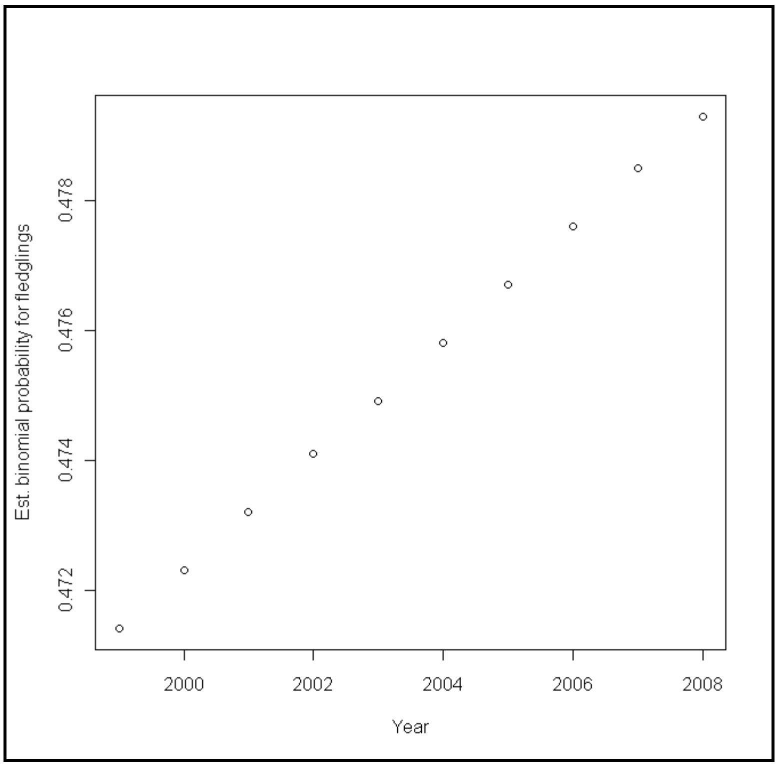


**Figure SOP 5.4.** Estimated binomial probabilities for spotted owl fledglings by year.

### *1.2.3 Habitat Analysis and Modeling*

Nest site measurements collected in the field will provide ample opportunities for data exploration. Trends in NSO nest type and habitat features may be analyzed by testing whether mean parameter values differ by year using ANOVA analysis. Post-hoc tests and graphical analysis will be used to examine significant test results. Tests of specific parameters will help to confirm patterns observed in the field, such as shifts in elevation, towards forest edges, or changes in nest tree species. Broader understanding of NSO habitat associations, however, must take a more unified approach that incorporates both field measurements and landscape variable derived from other sources.

New information about NSO habitat associations from this region could have important management and ecological implications and will therefore be explored by the SFAN monitoring program as a component of long-term trend analyses. A GIS modeling approach that relates NSO nest site occurrence and reproductive success to important habitat variables may help to explain any long-term trends detected in the monitoring data. The SFAN has already developed a GIS model for nest site occurrence in a collaborative effort with PRBO (Stralberg et al. 2009). The SFAN approach to modeling NSO habitat associations within the project area in future modeling efforts is outlined below.

Analyzing spatial relationships can be instrumental in determining many aspects in the lives of wildlife including their distribution and abundance. Wildlife-habitat models are an important tool in wildlife management for describing habitat selection and habitat quality. Almost any wildlife -habitat model that can be described in terms of mapable habitat features can be developed with GIS. To accurately describe a relationship between wildlife and habitat variables, model development should be a well thought out and well documented process and modeling results should be viewed with skepticism. The accuracy and biological meaningfulness of the inferences ultimately depends on the models included in the candidate set (Johnson and Omland 2004). With that in mind, the increase of GIS technology and model selection techniques provides an opportunity to spatially investigate otherwise latent biological patterns.

A critical component in evaluating habitat selection is to include the influences of spatial and temporal scale on ecological processes (Wiens 1989). Multiple years of data can be incorporated into analyses to provide insight into processes over time and data can be evaluated at multiple spatial scales. A subset of the dataset should be withheld for the purpose of model validation.

In the case of northern spotted owls, the concept of habitat selection extends beyond the physical attributes of vegetation and topography to incorporate the influence of the environmental variation associated with climate, prey, intraspecific and interspecific interactions (e.g., competitors, predators, parasites, disease), and time lags (e.g., delayed response to changing habitat conditions due to site fidelity). Factors affecting spotted owl demographic rates have been related to vegetation, weather, barred owls, prey, density-dependent factors, and interaction among factors (Franklin et al. 2000; Courtney et al. 2004; Olson et al. 2004; Dugger et al. 2005).

Biotic and abiotic information collected at nest tree locations used in conjunction with GIS derived layers provides an opportunity to evaluate third-order habitat selection (Johnson 1980) of spotted owl territories. One approach to evaluate third-order habitat selection would be to compare occupied nest sites with an equal, but random sampling of unused, available sites within an individual's home range or a specified spatial scale to evaluate selection at a fine spatial scale using the resource selection function (RSF) approach (McDonald et al. 1990).

The spotted owl location data can be created using our northern spotted owl master database for Marin County. The general work flow for model development is a multiple step process that includes: 1) identification of variables to include in the model 2) gathering and assembling spotted owl data and GIS data, 3) processing and prepping the variables in GIS, 4) construction of *a priori* models, and 5) regression analysis and $AIC_o$ ranking to evaluate model performance.

*Step1: Variable identification*
The selection of variables will be based on a review of existing literature describing factors influencing habitat associations of spotted owls and the spotted owl's primary prey (dusky-footed woodrat) in the study area (Table SOP 5.7). A majority of the variables likely to be included were identified in a nest site occurrence model for Marin County (Stralberg et al. 2009).

*Step 2: Gathering and assembling spotted owl and GIS data*
To create a spotted owl dataset for the analysis, the selection criteria would be based on the objective of the model. Appropriate information can be queried from master database and assembled in a spreadsheet. Existing slope, aspect, elevation, aerial imagery, vegetation (Schirokauer et al. 2003), hydrology (i.e., streams), boundary, and infrastructure (i.e., roads and trails) data layers for the San Francisco Bay area are available from the GIS drives at PORE and GOGA.

*Step 3: Process and prep the variables in GIS*
For each variable, the spotted owl activity centers (i.e., nest or roost location) would be the focal location for calculating spatial conditions. The shape and size of the analysis area will be based on purpose of the analysis. For each focal location, a set of spatial metrics would be calculated from GIS layers representing the habitat variables. Point metrics would reflect conditions at a specific location (e.g., nest site). Landscape metrics would be calculated around focal locations using a predefined radius or radii. The pixel size used in GIS analysis would be based on accuracy and specificity needs; however it would likely be completed using a 10m x 10m resolution. Point and landscape metrics would be calculated using ArcGIS 9.3.1 and standard extensions (ESRI 2009; Table SOP 5.7). Before processing any GIS data, all layers would be projected in the same geographic coordinate system (North American Datum 1983), all layers would have the same projection (UTM Zone 10), and the analytical environment would be set to the pixel size chosen to best represent the data.

*Step 4: Construction of a priori models*
*A priori* models would be constructed based on the variables hypothesized to be important based on literature support. Once all GIS values are obtained and entered in a spreadsheet, then the data table could be converted to a text file and imported into the statistical program R. To test for redundancy in explanatory power among habitat variables, a correlation analysis would be completed to identify variables with moderate to high correlation ($r \geq 0.60$) within each of the hypothesized models. The models including correlated variables would be removed from the analysis. An information-theoretic approach would be used to evaluate competing models (Burnham and Anderson 2002). The goal is to build the simplest model that describes the relationship between the habitat variables and the response variable.

*Step 5: Complete regression analysis and AIC ranking to evaluate model performance*
Akaike's Information Criterion adjusted for small sample size ($AIC_c$; Akaike 1973; Burnham and Anderson 2002) would likely be used to compare and select among candidate models. The goal would be to include the smallest number of predictor variables necessary to make good

predictions. Model ranking and selection of "best" models within the study area would be based on $AIC_c$ (Akaike 1973; Burnham and Anderson 2002). If $\Delta$AIC among the top tier of models is <2, model averaging will be considered. Otherwise, the most parsimonious model will be selected (Burnham and Anderson 2002).

**Table SOP 5.7.** Point and landscape metrics to be considered in *a priori* habitat models.

| **Point Variables** | **Reasoning for Variable Consideration** |
|---|---|
| Slope position (proportion) | nest sites found in watershed are more likely to occur on lower portions of slope (Blakesley 1992; LaHaye and Gutierrez 1999; Folliard 2000; Stralberg et al. 2009) |
| South aspect (degrees) | important variable in Stralberg et al. (2009) for nest site occurrence; highest densities of woodrat houses on south facing aspect (136 – 270 degrees; Willy 1992) |
| Distance to nearest stream (m) | woodrat (primary prey species) live near small streams due to higher amounts of food resources (English 1923) |
| Distance to forest edge (m) | measure of fragmentation and possible effects on prey densities |
| Distance to nearest road (m) | measure of fragmentation and possible source of nest site disturbance |
| Sudden Oak Death severity index (0-10) | impacts to canopy closure, acorn production for woodrats (NSO prey), and increased fire risk |

| **Landscape Variables** | **Reasoning for Variable Consideration** |
|---|---|
| Mean elevation (m) | productivity was greatest at lower elevations (LaHaye et al. 1997, Bart and Forsman 1992); important variable in Stralberg et al. (2009) for nest site occurrence |
| Elevational position in watershed | important variable in Stralberg et al. 2009 for nest site occurrence |
| Proportion of edge | measure of forest fragmentation; increased food resources; influenced habitat fitness potential (Franklin et al. 2000; Dugger et al. 2005) |
| Total forest edge length (m/ha) | increased food resources (Franklin et al. 2000; Dugger et al. 2005) |
| Mean slope (degrees) | variable in Stralberg et al. 2009 for nest site occurrence |
| Percent canopy cover | associated with high canopy cover (Forsman et al. 1984); possible variable in future; data not available at this time |
| Proportion of old growth trees | Possible variable in future; need LIDAR imagery to tease out residual trees |
| Forested proportion | important variable in Stralberg et al. (2009) for nest site occurrence |
| Conifer proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Hardwood proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Douglas-fir proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Redwood proportion | variable in Stralberg et al. (2009) for nest site occurrence |

| Landscape Variables (cont.) | Reasoning for Variable Consideration |
|---|---|
| Bishop pine proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Oak (tanoak/coast live) proportion | important forage and cover for prey (Atsatt and Ingram 1983; Sakai and Noon 1993) |
| California bay laurel proportion | variable in Stralberg et al. (2009) for nest site occurrence; Willy (1992) found that California bay laurel was a plant of local importance to woodrats |
| Shrub proportion | harbor abundant prey base; Willy (1992) found links to plant species associated with shrub species. However, this might be a result of forest/shrub edge effect. |
| Grass proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Urban proportion | variable in Stralberg et al. (2009) for nest site occurrence |
| Coarse woody debris (CWD) | Possible variable in future; woodrats use CWD in house construction; Chow (2001) roosts were associated with large, downed woody material |
| Sudden Oak Death proportion | Quantify tree mortality with aerial imagery |

| Covariates | Reasoning for covariate consideration |
|---|---|
| Weather | Timing of weather patterns (temperature and precipitation) influences reproductive success (Franklin et al. 2000) |
| Barred owl | Competitor and possible predator |
| Great-horned owl | Competitor and predator |
| Female age | Effects of female age on productivity (e.g., Anthony et al. 2006) |

### *1.2.4 Barred Owls*

The increasing numbers of barred owls in Marin County are anticipated to have significant, long-term impacts on the NSO population within the NPS study area. Long-term trend reports will summarize our current knowledge of barred owls within the study area and their perceived impacts on the NSO population. Reported barred owl information will include the following and may be expanded upon:

- Number of barred owl resident singles and pairs
- Location of barred owl resident singles and pairs (map)
- Known reproductive outcomes of nesting barred owls
- Number of banded barred owls (if applicable)
- Percentage of NSO territories where barred owls have been detected
- Percentage of NSO territories where barred owls have been detected that are now unoccupied
- Average proximity of NSO activity centers to barred owl activity centers
- Summary of observations of barred owl and NSO interactions

Barred owl presence will play an important role in the long-term analyses of the NSO occupancy and fecundity data and habitat selection models. As described in the previous sections of this

SOP, barred owl presence will be included as an explanatory covariate in occupancy, fecundity and habitat analyses.

### *1.2.5 Sudden Oak Death*

The long-term effects of SOD on NSO are unknown. However, with more openings in the forest canopy from fallen trees, reduced acorn crops affecting woodrat populations, and increased fuel load for wildfire, the potential effects of SOD on NSO populations is significant. SOD presence and severity may be an explanatory variable in the long-term trends of NSO occupancy, fecundity, and habitat selection. As described in the previous sections of this SOP, SOD will be included as an explanatory covariate in occupancy, fecundity, and habitat analyses.

SOD severity data will be collected at each nest or established activity center monitored each year (see protocol narrative Section 3.4.2 and SOP 2 Section 6.3.2). Additional SOD data available for inclusion in our analyses would come from other sources. For example, in 2010, PORE submitted a US Department of Agriculture grant proposal to quantify the potential impacts of SOD on NSO within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests.

## 1.3 Report Formats

All documents produced by the NSO monitoring program will be published in either the Natural Resource Report Series or the Natural Resource Technical Report Series following guidance from the NPS Natural Resource Program Center in Fort Collins, CO. Published reports will adhere to a set of strict formatting standards and are peer-reviewed to ensure that information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. The Natural Resource Publications Management home page hosts a list of all documents published in the NRR and NRTR Series. The home page can be found at:

http://www.nature.nps.gov/publications/NRPM/

# 4.0 Other Reporting

## 4.1 USFWS Permit Reporting

The SFAN NSO monitoring program is currently not required to operate under a USFWS Endangered Species Act Recovery Permit, because the monitoring study is largely observational (with calling). The monitoring program does not include banding, otherwise handling owls, or climbing to nests, so a “take” is not expected as a result of typical monitoring activities.

## 4.2 Annual Administrative Report and Workplan

The Lead Biological Technician provides annual administrative updates to the I&M Program Manager in August of each year for inclusion in the Annual Administrative Report and Workplan. The update includes project highlights, summary of work completed, volunteer hours summarized by park, budget, and expected budget for the next fiscal year.

### 4.3 SFAN Natural Resource and Science Monthly Updates

Interesting findings and project highlights are disseminated once or twice per season through the monthly SFAN update. This one-page monthly report series is distributed by email to park and network staff. Highlights are presented in short paragraphs with photographs. The update is developed and distributed by the I&M program, and includes information from I&M and from the park Natural Resources and Science divisions.

### 4.4 Resource Briefing

At the end of the field season, a resource briefing should be updated and reposted to the I&M website. The briefing is a two-page summary of NSO monitoring and provides information to park and network staff.

### 4.5 Website Updates

The SFAN I&M program maintains a public website with a page devoted to the NSO monitoring program. At the beginning and end of the field season, the public website should be updated with any new reports or information about the monitoring.

### 4.6 Project Presentations

Annually, results should be presented formally to park staff at GOGA and PORE. Presentations in the past, for example, have been given through the PORE lunch-time seminar series, the GOGA educator’s symposium, or the SFAN Natural Resource and Science Symposium. Posters or presentations are also encouraged at scientific meetings such as The Wildlife Society, Conservation Biology, Ecological Society of America or other meetings of regional or national scope.

## 5.0 Report and Data Dissemination

For the NSO monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the NSO monitoring documents and data will be the Internet. The NSO monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website:

http://science.nature.nps.gov/im/units/sfan/

Following review and approval by the NPS region’s key official, the finalized NSO documents will be distributed as soon as possible. After new postings to the SFAN website, each cooperator will be notified of newly available documents. Cooperators include PORE, GOGA, Muir Woods National Monument, PRBO Conservation Science, Marin Municipal Water District, Marin County Open Space District, and the State Park Ecologists at Tomales Bay and Samuel P. Taylor State Parks.

The NPS I&M Program maintains an on-line natural resource bibliographic database known as NatureBib. NatureBib records will be created for all of the NSO monitoring documents, including the protocol, annual reports, and any resulting publications. The public version of NatureBib is in development by the NPS I&M program.

## 5.2 Data Dissemination

All data collected are public property and subject to requests under the Freedom of Information Act (FOIA). However, sensitive data, such as the location of rare species, must be withheld. While the NSO monitoring database will not be posted for public download a metadata record for the database will be maintained at the NPS Data Store. The metadata record will direct interested parties to the SFAN Data Manager for further inquiries. Metadata requirements and distribution detail are included in SOP 4: Data Management Handbook.

NSO activity site locations and status information are provided to a number of agencies. This way we ensure that our work is available to county and state planners and contractors as they plan for projects in and around Marin County. Sharing of electronic information should only occur after all the data have been proofed and error-checked, and all site status determinations are complete. Ideally, the data dissemination would be accompanied by the annual report, but that may not always be possible, depending on the length of time required for report review and approval.

All areas surveyed and owl detections are mapped using GIS software programs, and GIS layers and metadata are provided to agencies involved in land management and planning in Marin County. Map layers are made available to park staff for park planning and compliance projects.

### *5.2.1 BIOS Data Submission*

The California Department of Fish and Game maintains the central repository for California NSO location information in the Biogeographic Information and Observation System (BIOS) data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. BIOS is the preferred central contact for dissemination of NSO data to appropriate parties. All sites surveyed for any purpose are included in the reporting to California Department of Fish and Game.

The BIOS data submission will include:

- GIS shapefile (must include prj, sbn, shx, sbx, and shp files)
- associated metadata record in both XML and TXT format

A zipfile should be created to package these products prior to distribution. SOP 4: Data Management Handbook provides detailed directions for developing the GIS shapefile and metadata records.

Instructions for submitting data to BIOS are available on-line:
http://bios.dfg.ca.gov/submitting_data.asp

Email electronic copies of a cover letter, GIS shapefile, and metadata files to:

Ray McDowell, BIOS Database Coordinator
Department of Fish and Game
rmcdowell@dfg.ca.gov

# 6.0 Literature Cited


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# Appendix SOP 5A. R code for occupancy and fecundity estimation and trend analysis.

**1. Download and open R.**

Go to http://www.r-project.org/ and click on "CRAN" in the left-hand menu. Choose a CRAN mirror site. Under "Download and Install R," select the appropriate platform then click on "base." From here, the installation files may be downloaded and run. Load the version of R that matches the version under which the VGAM package was written (currently version 2.9.2). Unfortunately, you will not know if they match until you install R and run the VGAM package, but an error message will occur if the versions do not match.

Open R and install the VGAM package. Click on the menu item "Package" then select "Install package(s)." Select a CRAN mirror site then scroll to the bottom of the drop-down list and select VGAM. Load the package by typing " library(VGAM)" (without the quotes) at the R prompt. After an R package is installed, it must be loaded every time it is used in a new R session.

**2. Read the data file.**

To read a data file into R, first change the working directory to the directory in which the data are stored by selecting "File\Change dir…" and selecting the appropriate directory. The data should be saved as a tab-delimited text file with a header in the first row to use the following command:

SPOWOcc<- read.table("SPOWOcc.txt", header=TRUE, sep = "\t")

For this example, the pilot data for the occupancy and fecundity analyses are provided in Appendix SOP 5B. Copy and paste the two commands into R to obtain the pilot data.

3. **Obtain models for occupancy and detection.**

Model selection is conducted using AIC as the selection criterion. Use site-level, year-level, and site-by-year level predictors for the occupancy model and use variables measured at the visit level for detection models. Compare each pair of occupancy and detection models and obtain the set that provides the lowest AIC value. The R code provided in the next step may serve as a template for coding occupancy and detection models for the VGAM package. AIC values may be obtained with the following function call for a model names "fit": `AICvlm(fit)`.

If a fit generates a warning message like the following, then a regularity condition has been violated and the standard errors may be calculated in error:

```
Warning messages:
1: In checkwz(wz, M = M, trace = trace, wzeps = control$wzepsilon) :
213 elements replaced by 1.819e-12
```

The standard errors of the predicted values may be quite large, which can be checked by examining the output of the `predict.vglm` function. If this warning message is obtained, this model may produce erroneous standard errors. Select a different model that meets regularity conditions.

**4. Estimate occupancy and obtain confidence intervals.**

# The following function is used for the estimation of occupancy and detection
# rates with the models obtained by comparing AIC values. The occupancy
# model contains terms for the year and an indicator of core sites. The detection
# model depends only on the month in which the survey was conducted.

```
SPOWlik.implicit <-function(parms,vars, data){

tmp<-rep(0,7)
names(tmp)<-c("pconst","psiconst", "year.o", "barred", "daytime",
"call", "obsnum" )
tmp[vars]<-parms

OccData<-data.frame(unique(cbind(data$Year, data$Barred)))
names(OccData)<-c("Year", "Barred")
M<-dim(OccData)[1]

DetData<-data.frame(unique(cbind(data$Daytime, data$Call,
data$ObsNum)))
names(DetData)<-c("Daytime", "Call", "ObsNum")
T<-dim(DetData)[1]

Rows<- dim(data)[1]
ones.Occ<-rep(1,M)
ones.Det<-rep(1,T)
year.o<- OccData$Year
barred<- OccData$Barred
daytime<-DetData$Daytime
call<- DetData$Call
obsnum<- DetData$ObsNum

# Model detection probs:
pmat<-expit(tmp[1]*ones.Det + tmp[5]*daytime + tmp[6]*call +
tmp[7]*obsnum)
# Model occupancy rates
psi<-expit(tmp[2]*ones.Occ + tmp[3]*year.o+ tmp[4]*barred)

LogLik<-rep(NA,M)
ymat<-data$PR

for(i in 1:M){                                  # Site loop
prob<-rep(1,T)
for (t in 1:T) {                        # YEAR loop
```

```
index<-(1:Rows)*as.numeric((data$Year== OccData[i,1]) & (data$Barred==
OccData[i,2]) & (data$Daytime== DetData[t,1]) & (data$Call==
DetData[t,2]) & (data$ObsNum== DetData[t,3]))
index<-index[index!=0]
m<-length(index)
  if(m>0) {
          yvec<-ymat[index]
          ysum<-sum(yvec)
          nodet<-as.numeric(ysum==0)

# Calc Log likelihood

prob[t]<- ((psi[i]* pmat[t])^ysum)*((1- (psi[i]*pmat[t]))^(m-ysum))

          }                                      # end if

  }                                              # End Year loop
# Calc prob of occurrence for each site
       LogLik[i]<-log(prod(prob))
   }                                             # End Site loop
    sum(-1*LogLik)
}
```

# Copy and paste these general functions into R for summarizing results:

```
expit<-function(x) ifelse(x>700,1,exp(x)/(1+exp(x)))
logit<-function(x) log(x/(1-x))
```

# Obtain the occupancy and detection models. Analysis of the pilot data indicated # that more accurate estimates were obtained by obtaining reasonable starting
# values for the regression parameters. Initial parameter estimates are obtained
# for the full occupancy model from a simple logistic regression fit that assumes
# perfect detection. Note that the intercept estimate is used as the initial estimate
# for the intercepts of both the occupancy model and the detection model.

```
fit.full.logreg<-glm(PR~ Year + Barred + Daytime + Call + ObsNum,
family = binomial, data=SPOWOcc)
summary(fit.full.logreg)

# Partial output:

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.29133    0.74572   5.755 8.69e-09 ***
Year        -0.10688    0.02479  -4.312 1.62e-05 ***
Barred      -0.37174    0.22689  -1.638   0.1013
Daytime      1.75383    0.13030  13.460  < 2e-16 ***
Call        -4.02091    0.71337  -5.636 1.74e-08 ***
ObsNum       0.19897    0.08109   2.454   0.0141 *
```

# Obtain maximum likelihood estimates for the regression parameters.

```
v= c("pconst","psiconst", "year.o", "barred", "daytime", "call",
"obsnum" )
x<-nlm(SPOWlik.implicit, p=c(4.29133, 4.29133, -0.10688, -0.37174,
1.75383, -4.02091, 0.19897),vars=v, data=SPOWOcc,  hessian=TRUE)
```

# Note that the output includes two warnings that "NA/Inf" replaced by maximum
# positive value."  This indicates that the Hessian matrix is not positive-definite
# and the standard errors may be inaccurate.  This model is used for trend testing
# with the likelihood ratio test which is not affected by the Hessian matrix.  The
# model that excludes the year term was found to have lowest AIC and a positive-
# definite Hessian matrix.

# Examine the fitted values of occupancy and detection rates:

```
phat<-expit(data.matrix(cbind(1, SPOWOcc[,6:8]))%*% data.matrix(x
$estimate[c(1,4:6)]))
pihat<-expit(data.matrix(cbind(1, SPOWOcc[,c(1,5)]))%*%
data.matrix(x$estimate[c(2:4)]))
unique(cbind(Barred=SPOWOcc$Barred, Daytime=SPOWOcc$Daytime,
Call=SPOWOcc$Call, ObsNum=SPOWOcc$ObsNum,
pihat=round(pihat,4),phat=round(phat,4)))
```

# Obtain estimated occupancy probabilities and CI's using the invariance property of
# MLEs.  Account for the fact that VGAM predicts the probability that site is
# unoccupied:

```
X.Occ<- data.matrix(cbind(1, SPOWOcc[,c(1,5)]))
Beta.Occ<- data.matrix(x$estimate[2:4])
Var.Beta.Occ<-solve(x$hessian)
yhat<- X.Occ%*% Beta.Occ
SE.yhat<-sqrt(diag( X.Occ%*% Var.Beta.Occ[2:4,2:4] %*% t(X.Occ)))
```

# Estimated occupancy near 1 and estimated SE's near 0 generate a Hessian matrix
# that is not positive-definite.

```
alpha<-0.20
Z.alpha<- qnorm(1-alpha/2)
OccCILow.Untrans<- yhat - Z.alpha* SE.yhat
OccCIHigh.Untrans<- yhat + Z.alpha* SE.yhat
OccCILow <-expit(OccCILow.Untrans)  # CI low of prob occupied
OccCIHigh <-expit(OccCIHigh.Untrans)      # CI low of prob occupied
Occ.Ests<-data.frame(round(cbind(Year=SPOWOcc$Year+1999,
Barred=SPOWOcc$Barred, Daytime=SPOWOcc$Daytime, Call=SPOWOcc$Call,
ObsNum=SPOWOcc$ObsNum, pihat= expit(yhat), OccCILow, OccCIHigh),4))
names(Occ.Ests)<-c("Year", "Barred", "Daytime", "Call", "ObsNum", "pihat",
"pihat.CI.Low", "pihat.CI.High")
unique(Occ.Ests[order(Occ.Ests$Year, Occ.Ests$Barred, Occ.Ests$Daytime,
Occ.Ests$Call, Occ.Ests$ObsNum),])
```

## 5. Test for decreasing trend in occupancy.

# Plot occupancy estimates by year:

```
PiByYr<-data.frame(unique(cbind(Yr= SPOWOcc$Year+1999,Barred= SPOWOcc$Barred,
pihat=pihat)))
names(PiByYr)[2:3]<-c("Barred", "pihat")

plot(PiByYr$Yr, PiByYr$pihat, ylim=c(0,1), pch="")
points(PiByYr$Yr[PiByYr$Barred==1], PiByYr$pihat[PiByYr$Barred==1], pch=1)
points(PiByYr$Yr[PiByYr$Barred==0], PiByYr$pihat[PiByYr$Barred==0], pch=2)
legend(2000, .3, pch=1:2, legend=c("Barred owl presence", "Barred owl
absence"))
```

# The plot indicates that sites with barred owl presence exhibited substantially
# lower occupancy levels in the most recent three years.

# To conduct the likelihood ratio test for trend, a reduced model that excludes the
# year term in the occupancy model is fit and compared to the full model to
# determine if the year coefficient is significantly smaller than zero.
# Obtain starting values for the reduced occupancy model from a simple logistic
# regression fit that assumes perfect detection.

```
fit.red.logreg <-glm(PR~ Barred + Daytime + Call + ObsNum, family =
binomial, data=SPOWOcc)
summary(fit.red.logreg)

# Partial output:

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  3.69101    0.73203   5.042 4.60e-07 ***
Barred      -0.58602    0.22111  -2.650 0.008042 **
Daytime      1.80314    0.12919  13.958  < 2e-16 ***
Call        -4.12134    0.71308  -5.780 7.49e-09 ***
ObsNum       0.28480    0.07892   3.609 0.000307 ***

v2= c("pconst","psiconst", "barred", "daytime", "call", "obsnum" )
x2<-nlm(SPOWlik.implicit, p = c(3.69101, 3.69101, -0.58602, 1.80314, -
4.12134, 0.28480),vars=v2, data=SPOWOcc,  hessian=TRUE)

chisq.test<- 2*( x2$minimum-x$minimum)
p.value<-pchisq(chisq.test, 1, lower.tail=FALSE)
c(chisq.test, p.value)
```

# We reject null hypothesis of a one-sided test of decreasing trend if the p-value is
# greater alpha and if the coefficient for the trend from the full fit is negative.
# Here we are testing at the 0.20 level so this p-value <0.0001 indicates that
# a significant decline has occurred in the occupancy trend.

## 6. Estimate detection rates and obtain confidence intervals.

```
X.Det<- data.matrix(cbind(1, SPOWOcc[,6:8]))
Beta.Det<- data.matrix(x$estimate[c(1,5:7)])
Var.Beta.Det<-solve(x$hessian)
yhat.Det <- X.Det %*% Beta.Det
SE.yhat.Det <-sqrt(diag( X.Det %*% Var.Beta.Det [c(1,5:7), c(1,5:7)] %*%
t(X.Det)))

DetCILow.Untrans<- yhat.Det - Z.alpha* SE.yhat.Det
DetCIHigh.Untrans<- yhat.Det + Z.alpha* SE.yhat.Det
DetCILow <-expit(DetCILow.Untrans)
DetCIHigh <-expit(DetCIHigh.Untrans)
Det.Ests<-data.frame(round(cbind(Year=SPOWOcc$Year+1999,
Daytime=SPOWOcc$Daytime, Call=SPOWOcc$Call, ObsNum=SPOWOcc$ObsNum,
phat=expit(yhat.Det), DetCILow, DetCIHigh),4))
names(Det.Ests)<-c("Year", "Daytime", "Call", "ObsNum", "phat",
"phat.CI.Low", "phat.CI.High")
unique(Det.Ests[order(Det.Ests$Year, Det.Ests$Daytime, Det.Ests$Call,
Det.Ests$ObsNum),])
```

## 7. Estimate fecundity and obtain confidence intervals.

The VGAM package allows the separate modeling for occupancy and detection rates. A list of matrices, denoted as H, is used to indicate in which model each term occurs. An intercept falls into both the occupancy and the detection model, so the H matrix for the intercept term is a 2x2 matrix with rows indicating regression terms and columns indicating occupancy and detection model inclusion, respectively. The Year and Barred terms were included in the occupancy model only and the Daytime, Call, and ObsNum terms were used to predict detection rates, so each of these terms includes only one column. For more help with model specification in VGAM, use `help(constraints)` or see the following link:

[http://www.stat.auckland.ac.nz/~yee/VGAM/doc/VGAM.pdf](http://www.stat.auckland.ac.nz/~yee/VGAM/doc/VGAM.pdf).

# Load the VGAM library.

library(VGAM)

# Create "H" matrices to specify the models for fecundity rate and the probability
#  of not obtaining a zero:

```
H1<-matrix(c(1,0,0,1),2,2)      # Intercept terms
H2<-matrix(c(0,1),2,1)          # Year term
Hlist<-list("(Intercept)"=H1, YEAR=H2)
fit.full = vgam(NUMFLEDG/3 ~ YEAR, zibinomial(zero=NULL),
constraints=Hlist, data= SPOWFec, maxit=1000,
weight=rep(3,dim(SPOWFec)[1]))
```

# Obtain the estimates of the regression coefficients:

```
Coefs<-Coef(fit.full)
Coefs
```

# Obtain estimates of the fledgling fecundity rate:

```
Fec.Ests<-predict.vglm(fit.full, se.fit=TRUE)
alpha<-0.20
Z.alpha<- qnorm(1-alpha/2)
FecCILow.Untrans<-Fec.Ests$fitted.values[,2]- Z.alpha* Fec.Ests$ se.fit[,2]
FecCIHigh.Untrans<-Fec.Ests$fitted.values[,2]+ Z.alpha* Fec.Ests$
se.fit[,2]
FecCILow <-expit(FecCILow.Untrans)        # CI low
FecCIHigh <-expit(FecCIHigh.Untrans)      # CI high
Fec.Ests.CI<-data.frame(round(cbind(Year=SPOWFec$YEAR+1999,
phat=expit(Fec.Ests$fitted.values[,2]), phat.CI.Low =FecCILow,
phat.CI.High =FecCIHigh),6))
unique(Fec.Ests.CI[order(Fec.Ests.CI$Year),])
```

# Obtain estimates of the probability of not observing an extra zero:

```
ProbZero<-1-expit(Coefs[1])
ProbZero.CILow.Untrans<- Fec.Ests$fitted.values[,1]- Z.alpha* Fec.Ests$
se.fit[,1]
ProbZero.CIHigh.Untrans <-Fec.Ests$fitted.values[,1]+ Z.alpha* Fec.Ests$
se.fit[,1]
ProbZero.CILow <-expit(ProbZero.CILow.Untrans)
ProbZero.CIHigh <-expit(ProbZero.CIHigh.Untrans)
unique(round(cbind(ProbZero, CILow=ProbZero.CILow,
CIHigh=ProbZero.CIHigh),4))
```

**8. Test for decreasing trend in fecundity.**

# Compute the likelihood ratio test for trend:

```
H1<-matrix(c(1,0,0,1),2,2)      # Intercept terms
H2<-matrix(c(0,0),2,1)   # Year term - excluded
Hlist2<-list("(Intercept)"=H1, Year=H2)
fit.red = vgam(NUMFLEDG/3 ~ 1, zibinomial(zero=NULL),
constraints=Hlist2, data= SPOWFec, maxit=1000,
weight=rep(3,dim(SPOWFec)[1]))
```

# Compute the p-value for LRT statistic:

```
chisq.test<- -2*(logLik(fit.red)- logLik(fit.full))
p.value<-pchisq(chisq.test, 1, lower.tail=FALSE)
c(chisq.test, p.value)
```

# Reject null hypothesis of a one-sided test of decreasing trend if p-value < alpha
# = 0.2 and if the coefficient for the trend is negative. Here we fail to reject the
# null hypothesis with a p-value of 0.9479.

# Appendix SOP 5B. Example pilot data for occupancy and fecundity analysis

*Occupancy data*

```
SPOWOcc <-
structure(list(Year = c(1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 7, 1, 3,
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8, 6, 7, 1, 6, 3, 6, 6, 6, 5, 5, 5, 4, 4, 4, 4, 4, 4, 4, 3, 3,
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0, 7, 7, 7, 0, 1, 0, 0, 0, 2, 7, 0, 2, 0, 0, 1, 1, 1, 1, 1, 2,
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"Arroyo Hondo", "Audubon Canyon", "Baldy Trail", "Barnabe North",
"Bear Valley", "Bike Path", "Bolema Trail", "Camp Eastwood",
"Cheda Creek", "Coppermine", "Devils Gulch", "Divide Meadow",
"Dogtown", "Eucalyptus Gulch", "Five Brooks", "Fox Drive", "Giacomini",
"Glen Trail", "Greenpicker Trail", "Haggarty Gulch", "Hagmaier Ponds",
"Homestead Valley", "Horse Trail", "Indian Beach", "Inverness Valley Inn",
"Jewell Trail", "Kent Canyon", "Lookout", "McCormick Creek",
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"McIsaac Gulch", "McKinnan Gulch", "Meadow Trail", "Morses Gulch",
"Mt Vision Road", "Mt Wittenberg", "Mud Lake", "Muir Woods",
"Old Pine Trail", "Olema Cemetery", "Pantoll", "Pike County Gulch",
"Pine Gulch N2", "Pine Gulch North", "Pine Gulch South", "Pioneer Tree Trail",
"Platform Bridge", "Randall Gulch", "Rifle Range", "Sir Francis Drake",
"Stewart Trail", "Stinson Gulch", "Swimming Hole", "Teixeira",
"Volunteer Canyon", "Webb Creek", "West Fir Top", "West Peters Dam",
"Wilkins Gulch", "Zanardi Ranch"), class = "factor"), Location = c(1L,
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# SOP 6. Safety Procedures
*Version 1.2*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| | Nov. 2007 | Dawn Adams | Created | To meet new formatting and content guidelines. | 1.0 |
| 1.0 | Feb. 2008 | Dawn Adams | Layout, added emergency #s | Edited for peer review | 1.1 |
| 1.1 | March 2010 | David Press | Added Section 3.0 on check in / check out procedures. | To formalize these procedures | 1.2 |

# Contents

This SOP provides safety information related to monitoring spotted owls at Golden Gate National Recreation Area (GOGA), Muir Woods National Monument (MUWO), and Point Reyes National Seashore (PORE). Also see SFAN Field Safety SOP maintained on the GOGA network drive: inpgogamahe1\Divisions\Network I&M\Shared\Standard Operating Procedures\SFAN Field SOPs\Standard Operating Procedures.

## 1.0 Weather and Field Attire

Summer conditions are often mild (between 60 - 80°F), but when conducting fieldwork along the coastal environment, it is important to dress appropriately for a range of weather conditions. Because of the possibility of encountering poison oak and general uneven terrain found off-trail, field personnel should wear long pants and high-topped hiking boots. Leg gaiters are also recommended to reduce the exposure to poison oak and the risk of tick bites during surveys. Since surveys can last longer than anticipated, field personnel are encouraged to take extra food and drinking water into the field.

## 2.0 Field Hazards

Biting or stinging invertebrates (wasps, spiders, ticks) may be encountered. The bites or stings from these animals can be painful, but usually not fatal. If bitten or stung and painful swelling or an allergic reaction occurs, seek medical attention immediately. Check your clothing and exposed skin frequently when in the field for ticks and upon returning from the field, do a more thorough body search for ticks.

Poison oak is found throughout the owl habitat in the study area. Before doing any fieldwork personnel should become familiar with the dangers associated with exposure to this native plant. If exposure occurs wash thoroughly with soap and rinse with plenty of water upon returning from the field and then apply Tecnu® ointment (provided at headquarters). If a strong reaction occurs, seek medical attention and alert your supervisor as soon as possible.

Appendix SOP 6A is the Job Hazard Analysis (JHA) for the spotted owl monitoring program. The JHA analyzes the duties, tasks, and potential hazards associated with the program, and addresses the hazards through safe work behaviors and procedures.

## 3.0 Check Out / Check In Procedures

When working in the field solo, whether during the day or at night, field staff should inform a supervisor, co-worker, or other responsible party of field plans and check back in at the end of the survey. At the beginning of the season, a list of field sites to be monitored should be developed that contains the geographic coordinates of the most recent activity centers. Coordinates should be in both UTM (NAD83, Zone 10) and Lat/Long (WGS 84). Detailed directions to the activity centers should be included, with trail and road names, distances, and off-trail landmarks. A copy of the site directions should be retained by all project staff and a copy should be given to park dispatch. If a spouse or housemate will be responsible for ensuring the safe return of staff after hours, a copy of the site directions should be left at home and should include pertinent phone numbers to call in case of emergency. Phone numbers should include those for other project staff (work, home, and cell), park dispatch, Marin County Sheriff, and 911.

At the beginning of the season, project staff should meet with NPS law enforcement staff to discuss possible safety concerns with any of the NSO sites planned for monitoring that year. If necessary, law enforcement staff may accompany the project staff on initial visits to sites of concern.

# Appendix SOP 6A. Job hazard analysis (JHA) for northern spotted owl monitoring activities.

| | | |
|---|---|---|
| **POINT REYES NATIONAL SEASHORE**<br>**Job Safety Analysis** | **Job Title: Spotted Owl Monitoring**<br>**page 1 of 3** | **Date: June 7, 2006**<br>**Analysis by: Heather Jensen, Dawn Adams** |
| **Division: SCIENCE** | **Title of person who does job: Biotechnician- Wildlife** | **Reviewed by: Sarah Allen** |
| **Location: PORE, GOGA, MUWO** | **Supervisor: Program Lead** | **Approved by:** |
| **Personal Protective Equipment: Long-sleeved shirt, thick pants, sturdy boots, eye protection** | | |
| **Training and/or certifications** | | **Permits** |

| **A. SEQUENCE OF BASIC JOB STEPS**<br><br>**Identify steps and sequence of work activities** | **B. POTENTIAL JOB HAZARDS**<br><br>**Task: Identify hazards in each basic step.**<br>**Site: Identify site hazards that could affect workers** | **C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT**<br><br>**Determine specific controls and safe behaviors for each hazard.** |
|---|---|---|
| **Office Work**- Computer use for email and data entry | Muscle and eye strain, repetitive stress injury | Proper posture and use of ergonomic furniture<br><br>Take breaks every hour |
| **Mouse care and use** | Mouse bites | Handle mice gently, lifting by the tails unless tails have injuries; use greater care when mice are agitated |
| **Owl capture and handling** | Talon cuts while handling owls<br><br>Being struck by adult owls when near juvenile owls | After capture, control owl's legs at all times<br>Keep talons and beak at a safe distance from face<br>Communicate location of adults clearly with your field partner, and have one person watching owls at all times<br>Wear a hat and/or glasses to protect face and eyes |
| **Travel to Field Locations** in Vehicle | Driving hazards such as accident | Use defensive driving techniques<br>Expect oncoming traffic on one-lane roads in park<br>Be alert for foggy conditions |

| A. SEQUENCE OF BASIC JOB STEPS<br><br>Identify steps and sequence of work activities | B. POTENTIAL JOB HAZARDS<br><br>Task: Identify hazards in each basic step.<br>Site: Identify site hazards that could affect workers | C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT<br><br>Determine specific controls and safe behaviors for each hazard. |
|---|---|---|
| | | Watch for deer, elk and other wildlife, and adjust speeds to safely operate around areas of high use<br>Obey traffic laws and wear seatbelt at all times<br>Do not drive when fatigued, be familiar with route or prepare for unknown route<br>Do not talk on radio or cell phone while driving<br>Do not put hot drinks on your lap<br>Be familiar with the vehicle and its operation<br>Check gauges, tires, wipers, fluids and replace when necessary<br>Check vehicle has spare tires, jumper cable and jack with all parts. |
| **Hiking to work areas** on trails, routes or off trail navigation | Working off trail<br><br><br><br>Getting lost or confused as a group<br><br>Losing a crew member | Consult with law enforcement staff about areas that may be unsafe to travel off trail. If needed, arrange to have law enforcement staff join the initial site visits and clear the area.<br>Have map and compass and other navigational aids and know how to use them.<br>Travel together when off-trail<br>Make sure both members of the team are aware of location, and can find route out if they are separated.<br>When trail hiking, plan stops at trail junctions to regroup.<br>Arrange meeting places and times -- all crewmembers must wear a watch.<br>Have a travel plan for each day and make sure it is understood by all crewmembers<br>Stay in communication via radio or stay in sight<br>Carry cell phone, radio and spare batteries<br>If lost or disorientated, stay calm, assess location by consulting map and landmarks, and proceed to |

| A. SEQUENCE OF BASIC JOB STEPS<br><br>Identify steps and sequence of work activities | B. POTENTIAL JOB HAZARDS<br><br>Task: Identify hazards in each basic step.<br>Site: Identify site hazards that could affect workers | C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT<br><br>Determine specific controls and safe behaviors for each hazard. |
|---|---|---|
| | | nearest road or trail.<br><br>Do not panic -- Have a mental plan for what to do if lost<br>If injured, stay put and call dispatch. |
| | Working at night | When possible, conduct night work in pairs. If working alone, leave a travel/survey plan with a supervisor, co-worker, or responsible party who will notify proper authorities in the event of a disappearance.<br>Carry a light source and extra batteries. |
| | Loose footing | When traveling in areas with steep or unstable terrain, stagger your positions so that you are not immediately below someone, yell "rock" if you dislodge one. |
| | Lightning storms | In the event of a lightning storm, turn your radio off, if near a vehicle, get entirely inside. If in the outdoors try to do the following: separate the group, get off ridge tops and away from trees, get as low as possible and if possible lie on non-conductive material. |
| | Wind storms | If it is windy enough to blow small twigs and branches out of the trees, try to get out of the woods or find an area away from hazard trees |
| | Exposure to cold, wet conditions | Wear proper equipment- and bring extra layers.<br>Recognize the signs of hypothermia in yourself and others<br>Carry and eat high-calorie foods, stay well-hydrated |
| | Exposure to heat and sun | Have hat, sunscreen and sunglasses |
| | Overexertion and dehydration | Recognize the signs of dehydration<br>Take frequent rest stops (15 min per every 2 hours) and stay hydrated |
| | Injuries due to hiking (aches, sprains and blisters) | Pay attention to footing- plan ahead for the route to avoid steep, unstable terrain |

| A. SEQUENCE OF BASIC JOB STEPS<br><br>**Identify steps and sequence of work activities** | B. POTENTIAL JOB HAZARDS<br><br>**Task: Identify hazards in each basic step.**<br>**Site: Identify site hazards that could affect workers** | C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT<br><br>**Determine specific controls and safe behaviors for each hazard.** |
|---|---|---|
| | Injuries due to falling (lacerations, broken bones, head injuries)<br><br>Injuries due to carrying a heavy pack | Use appropriate footwear, boots and socks.<br>Prevent blisters and have blister treatments (moleskin, tape etc) accessible.<br>Pay particular attention to traveling on steep slopes, unstable terrain, through dense vegetation, and in foggy conditions. Practice fall- arrest techniques (roll on to stomach, dig elbow, feet and knees in).<br>Have first aid kit, stabilize injured person, treat for shock and know how to initiate rescue via radio<br>Reduce pack weights when possible<br>Pay attention to how you put your pack on (avoid twisting motions- get help or place pack on surface or against tree)<br>Make sure your pack is properly fitted and balanced |
| **Hiking to work areas**- Stream and river crossings | Exposure, sprains, broken bones, drowning | Avoid swift or deep water crossings by using foot or automobile bridges.<br>Be careful on slippery logs and watch footing on either side of stream crossing. |
| **Working in the outdoors** | Exposure to allergy-causing plants and insects<br><br>Exposure to toxic plants | Alert crew members to possible problems with allergens. Be alert for toxic plants and alert to common bee and wasp nesting habitat and activity- especially the person in front.<br>Carry Benadryl, epi-pen or other antihistamine<br>Avoid poison oak when possible. Wear long-sleeved shirts, long pants, and<br>hiking boots. Wash skin exposed to poison oak with Tecnu or other appropriate cleaner and change clothes if necessary at end of day/survey.<br>Do not eat any fungus or plant unless you are 100% sure it is edible. |

| A. SEQUENCE OF BASIC JOB STEPS<br><br>Identify steps and sequence of work activities | B. POTENTIAL JOB HAZARDS<br><br>Task: Identify hazards in each basic step.<br>Site: Identify site hazards that could affect workers | C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT<br><br>Determine specific controls and safe behaviors for each hazard. |
|---|---|---|
| | Exposure to ticks | Wear proper attire (long-sleeved shirts and long pants) and do frequent tick checks. If bitten by black legged tick, properly remove tick, save tick, send tick in for lab analysis, and monitor general health condition. |
| | Exposure to giardia, E. coli and other pathogens | Do not drink any water unless it has been filtered, boiled or treated in some fashion |
| | | Do not create more contaminated areas- urinate away from streams and water, dig a cathole for solid waste and bury toilet paper.<br>Wash hands when possible and carry hand cleaner |
| | Improper nutrition due to inappropriate food choices | Bring a variety of healthy, nutritious food that will give you good energy during travel and work. Do not rely on sugar snacks. |
| | Loss of food to ravens, raccoons, small animals | Prevent animals from getting into your food by not leaving you backpack open or accessible to animals. |
| | Cougar attack | If approached by cougar make yourself large and noisy, wave arms, yell, grab a stick. Back away from cougars but do not turn and run, ever. If attacked, fight back. |
| | Strange or aggressive human interactions | Terminate contact with visitor and leave the area, contact dispatch (GOGA: 415-561-5656; PORE: 415-464-5170 or emergency numbers (911) |

# SOP 7. Revising the Protocol
*Version 1.2*

## Revision History Log

| Previous Version # | Revision Date | Author | Changes Made | Reasons for Change | New Version # |
|---|---|---|---|---|---|
| | Sept. 2007 | Marcus Koenen | Adapted from SFAN Water Quality Protocol | | 1.0 |
| 1.0 | May 2008 | Dawn Adams | Added App. A with reviewers comments and response | In prep for submitting to PWR. | 1.01 |
| 1.01 | March 2010 | David Press | Added App. B with reviewers comments and response. Added App. C and App. D also. Changed this SOP from SOP 8 to SOP 7. | In prep for submitting protocol for final approval. Removed SOP 7 After the Season from protocol. | 1.2 |

# Contents



# Tables

This standard operating procedure (SOP) explains how to make changes to the Northern Spotted Owl (NSO) Monitoring Protocol Narrative for the San Francisco Bay Area Network (SFAN) and accompanying SOPs, and tracking these changes. Editors of the Protocol Narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data is collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

# 1.0 Revision Procedures

The NSO Monitoring Protocol Narrative for the SFAN and accompanying SOPs has attempted to incorporate sound methodologies for collecting and analyzing spotted owl data. However, all protocols regardless of how sound require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken. The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol. The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.

All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by SFAN staff. However, if a complete change in methods is sought, than an outside review is required. Regional and national staff of the National Park Service (NPS) with familiarity in spotted owl monitoring and data analysis will be utilized as reviewers. Also, experts in spotted owl research, monitoring, and statistical methodologies outside of the NPS can be utilized in the review process.

Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0, etc.) Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require SOP modifications. The program tracks the narrative and SOP version numbers in a Master Version Table (MVT; Table SOP 7.1), which is maintained in this document (SOP 7). Anytime a narrative or an SOP version change occurs, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The VK number increments by whole integers (e.g., 1, 2, 3, 4, 5). The protocol narrative, SOPs, and data should not be distributed independently of this table.

Updates to the MVT and changes to the Protocol Narrative or SOP must be provided to the SFAN Data Manager for inclusion in the master version table database and the metadata record.

In addition, the database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.

Post new versions on the website and forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP, including spotted owl project staff from Golden Gate National Recreation Area and Point Reyes National Seashore. Archive older versions of the protocol narrative and SOPs on the network archive server under the Spotted Owl vital sign folder.

**Table SOP 7.1.** Master version table and current SFAN northern spotted owl protocol documents.

| Version Key # | Date of Change | Protocol Narrative | SOP 1 | SOP 2 | SOP 3 | SOP 4 | SOP 5 | SOP 6 | SOP 8 |
|---|---|---|---|---|---|---|---|---|---|
| VK1 | May 2008 | 6.3 | 1.2 | 1.3 | 1.2 | 1.1 | 1.2 | 1.1 | 1.01 |
| VK2 | July 2010 | 6.4 | 1.3 | 1.4 | 1.3 | 1.2 | 1.3 | 1.2 | 1.2 |

## 2.0 Protocol Reviews

A draft of the Northern Spotted Owl (NSO) Monitoring Protocol was submitted and reviewed by three reviewers in 2004 and to two additional reviewers in 2008. Appendix SOP 7A summarizes the major deficiencies and suggested corrective actions noted by the reviewers along with the authors' responses. The summary does not include layout, grammatical, spelling or table/figure change edit recommendations. Appendix SOP 7B documents all review comments with the authors' specific responses for the 2008 review. The authors' responses are documented in italics in both appendices. Hard copies of reviewer comments are on file at the San Francisco Bay Area Network Inventory and Monitoring office.

# Appendix SOP 7A: 2004 peer review comments and response from protocol authors.

A draft of the Northern Spotted Owl (NSO) Monitoring Protocol was submitted and reviewed by three reviewers in 2004. In 2007 and 2008, review comments were incorporated into the protocol. This appendix summarizes the major deficiencies and suggested corrective actions noted by the reviewers. This summary does not include layout, grammatical, spelling or table/figure change edit recommendations. The text in italics represents the changes made to the document based on the reviewer's comments. Hard copies of reviewer comments are on file at the San Francisco Bay Area Network Inventory and Monitoring office.

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Review #1: Dr. Patti Happe, Wildlife Branch Chief, Olympic National Park
patti_happe@nps.gov, Phone 360-565-3065

Reviewer expressed concern over dropping the demography study and banding program and consequent loss of survival information, which she values the more than reproductive metrics and sees the Marin population as an important contribution to a range-wide study.
*Due to funding and personnel constraints for overall SFAN vital signs monitoring program, the monitoring program could not continue the additional effort spent on banding at this time.*

Needs a better description of sample population and area of inference, how sample was selected.
*Revised protocol narrative included a better description of previous study design and its limitations. The revised study design and subsequent reselection of study sites was described in detail*.

Needs a better description of monitoring history.
*Revised protocol included information from additional monitoring studies and expanded on those previously described*.

Use more descriptive maps, include NSO range-wide map.
*Revised map included in protocol narrative: increased size, included NSO range inset, improved NSO habitat and park boundaries delineations, and provided better description in text. Authors desired the protocol to be a public document, so did not represent sites selected for monitoring in smaller scale maps*.

Data management section is missing metadata procedures.
*Metadata information included in revised protocol*.

Include more about why the NSO was federally listed, primary threats, and which threats apply to this population. Note absence of recovery plan and how it would apply to the SFAN area.
*Information from draft recovery plan (made available in August 2007) was included in narrative background section*.

Need support for 15% change threshold and description of what it means.
*Revised study design and power analysis used previous data to determine specific probabilities and length of time needed to detect 10% declines in fecundity and occupancy.*

Needs a better description of satellite database processes.
*Included in narrative and SOP.*

Is it necessary to continue nest characterization? Do we expect changes and would it change management actions?
*Authors determined that due to potential changes in nesting habitat from sudden oak death and ease of collecting the nest and habitat data warranted continuing the nest characterization.*

Review #2: Dr. Rocky Gutiérrez, Ph.D., University of Minnesota
gutie012@tc.umn.edu, Phone 612-624-2720
This reviewer provided the most extensive review comments throughout the protocol. Every comment is not addressed but some (e.g., sample design comments) are lumped into a single comment.

Details of sample design (randomization) and data analysis are unclear. The sampling and experimental design is not appropriate and sufficient to answer the monitoring questions and ensure statistical validity. The key issues are that no stratified random sampling design was employed and no specific analysis discussed. The current sample can be used but it limits inference to the sites monitored and not to the parks in general. Consider using MacKenzie detectability models or correct for survey effort when looking at changes in occupancy.
*Corrected through SFSU sample design analysis, reselection of random sample populations for occupancy and fecundity monitoring. SFSU analyzed past data to determine probability of detection (both day and night) for at least one owl and a pair of owls, and incorporated the detectability values into a power/sample size analysis for occupancy populations. The data analysis section and SOP was expanded and more detail provided.*

Need to expand discussion of the barred owl issue, and references to NSO Status review 2004. Barred owls should be a major reason for continued monitoring of spotted owls.
*Included additional results from status review and draft recovery plan, which expanded the barred owl issues range-wide and within Marin County.*

Relevant research on spotted owls in Marin County is not cited (Chow thesis).
*Additional information provided in narrative on Marin County owl studies including Nola Chow's thesis. Rearranged background sections on history of inventory, monitoring, and research.*

Protocol does not include clear and specific objectives for management action such as thresholds and or trends.
*Expanded information on management objectives and triggers for management actions, but specific thresholds and subsequent management actions have not been identified. If causes of*

*population declines can be determined, managers may be able to act accordingly or request additional research.*

Reporting section of protocol is incomplete, not well organized, and needs improvement.
*Reporting section revised to make clear the types of reports and reporting schedule.*

Protocol is missing example field forms, training manual, and facility and office needs section.
*Missing pieces included in revised protocol and expanded SOPs.*

Marin County NSO population is almost a closed population so if banding a large proportion of the small population, it is a powerful assessment of a population's status.
*Due to funding and personnel constraints for overall SFAN vital signs monitoring program, the monitoring program could not continue the additional effort spent on banding at this time. A new demography study is a research option if declines are detected.*

Overly ambitious set of monitoring objectives.
*Monitoring objectives were reduced and remaining ones were narrowed in scope.*

Reviewer suggested that the SFAN field season methods include having different monitoring teams check the same activity site as a check and balance.
*Not possible because of limited field staff and site access logistics, but instituted periodically and when possible.*

Emphasize need for hearing tests or adequate hearing ability in field personnel.
*Addressed in personnel requirements.*

Reviewer felt that survey stations set only 0.25 miles apart would lead to excessive survey stations and a 0.5 mile distance is suitable.
*Unlike other NSO areas, Marin has smaller canyons and terrain features, and prominent points are not as common. In addition, the area has a higher amount of vehicle and plane traffic which the authors felt necessitated more dense survey points. Protocol text was changed to "survey stations <u>a minimum of</u> 0.25 mile apart".*

Each member of a survey team should keep notes for future cross-referencing.
*Authors changed the protocol to indicate that if members of a field team split up during a survey, both are required to take notes with the designated survey notetaker responsible for compiling the notes at the end of the survey.*

Reviewer suggests collecting larger scale habitat metrics like size of patch, edge, etc.
*Larger scale habitat metrics were identified through GIS during the habitat model preparation, but data is not analyzed on an annual basis and would be part of a long-term trend analysis.*

Describe formal procedures for proof reading data.
*Description of quality assurance/quality control procedures were expanded in data management SOP and data entry, verification and editing sections of protocol.*

Reviewer questioned the purpose of the conceptual model appendix included in the original draft, which suggested that SFAN was developing a comprehensive model.
*Authors decided to remove model from protocol as it was no longer a requirement and apparently was not a critical piece of information needed to understand the monitoring objectives.*

Review #3: Dr. Reginald H. Barrett, University of California, Berkeley, **rbarrett@nature.berkeley.edu**, Phone 510-642-7261

Reviewer generally thought the protocol met all the requirements of the protocol checklist, but had a couple additional suggestions:

Add an organizational chart of all the staff and relationships.
*Revised protocol provides an expanded list of staff member involved in NSO monitoring and responsibilities, but authors felt that an organizational chart was not warranted.*

Provide a chart of all the data sets (files, etc.) with names and contact information for responsible staff.
*Additional network pathways for specific files were included in revised protocol. Due to expected turnover of staff, names and contact information were not included in protocol, but are provided on an annual basis to program staff and other cooperators.*

# Appendix SOP 7B: 2008 peer review comments and response from protocol authors.

A draft of the Spotted Owl Monitoring Protocol was submitted to Dr. James Agee, PWR Protocol Review Coordinator, and Dr. Penny Latham, PWR Regional I&M Coordinator in May 2008. Dr. Agee forwarded the protocol to two anonymous peer reviewers (R1 and R2). In 2009 and 2010, review comments were incorporated into the protocol. This appendix summarizes the deficiencies and suggested corrective actions noted by the reviewers. The text in italics represents the authors' changes to the document based on the reviewers' comments. Hard copies of reviewer comments are on file.

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UNIVERSITY OF WASHINGTON
College of Forest Resources Box 352100
University of Washington, Seattle, Washington 98195

James K. Agee, Emeritus Professor of Forest Ecology
Ph: 206-543-8242 Fax: 543-3254
112 Winkenwerder Hall
email: jagee@u.washington.edu

October 1, 2008

The scientific review for **"Northern Spotted Owl Monitoring Protocol"** for the San Francisco Bay Area Network Inventory and Monitoring Program is complete. The protocol receives the following decision:

**Needs Major Revision**

Attached to this letter are review and informational documents: (1) a PWR Protocol Review Checklist. Each question is addressed in the left column; if scientific, it is addressed by me and the word is in bold, and if administrative is addressed in normal font, as a "yes", "no", "in part", or N.A. [not applicable]. (2) The individual reviews are included with author's names erased, and reviewers are identified in this cover letter as R1 or R2. The reviews are self-explanatory, but what I attempt to do here is place them in an integrated context beyond the abbreviated response in the PWR Protocol Review Checklist.

The protocol is well-written and given the limited sample design, is presented well, with appropriate power analyses. Many of the earlier review comments (by NPS-selected reviewers) were addressed in the revision. Nevertheless, due to the high profile of the Northern Spotted Owl, I chose to send the protocol out for a blind peer review. While the protocol appears sufficient to "generally" inform managers from the San Francisco Network of national parks about the status and trends of Northern Spotted Owl breeding in these parks, both reviewers were in consistent agreement that this "general" protocol was insufficient. This is due to funding limitations that significantly limit the number of sites and visits, and possible incompatibility with data collected by other agencies.

Due to the high profile of this particular vital sign, the review was forwarded in mid-August to assigned NPS personnel (Drs. David Graber and Steve Fancy, together with Penny Latham) to evaluate its political status. Their response is that all NPS monitoring protocols will be exempt from the "highly influential" criterion, as these are just study plans, so that issue is now moot.

As I read the protocol, it does deviate from the Forest Service PNW Station standards, which I believe are those used by the other Federal agencies. If true, then more funding would be required to bring the protocol into compliance. The small sample size is less an issue if the methods are compatible with those of other agencies, so that this protocol can be part of a larger dataset. On its own, it will need a larger sample size. This is the most critical issue to be addressed in a response. If the plan is to be part of larger sample, then objectives will have to be revised to reflect that the monitoring will be less to draw conclusions about park owls and more to draw conclusions about larger geographic populations.

The comments of reviewers are attached here, and major points include:

A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

Methods are well-described but are unlikely to be effective in establishing <u>no</u> occupancy (R2).

There is a pressing need to correlate change in owl populations with causes, but neither sudden oak death nor barred owls will be monitored in sufficient detail to establish cause (R1, R2)

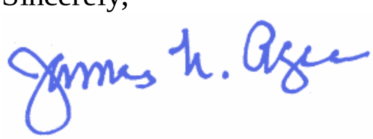
There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2)

Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

Long-term trend analysis needs more definition

Upon receipt of the protocol, due to the complex nature of the comments, I will send this out for another review to at least one reviewer. Please address each comment of the reviewers in detail.

Sincerely,



James K. Agee
National Park Service, Pacific West Region, Protocol Review Coordinator

PWR PROTOCOL REVIEW CHECKLIST
Protocol Name: SFAN Spotted Owl
Science Reviewer: **J.K. Agee** Admin. Reviewer: Mark Huff

| | Overall Organization and Presentation of Protocol Narrative |
|---|---|
| Yes | 1. Is the overall monitoring protocol well-organized with sections clearly delineated? |
| Yes | 2. Does the protocol have a title page with authors' names, protocol version number and date? (Protocol version numbers should be constructed to allow for both major and minor changes.) Is there a Table of Contents, abstract, and the three basic sections: 1-Narrative, 2-Standard Operating Procedures (SOPs), and 3-Supplementary Materials or Appendices recommended in the NPS standards published by Oakley et al. 2003 (http://science.nature.nps.gov/im/monitor/protocols/ProtocolGuidelines.pdf). |
| Yes | 3. Is there a complete and accurate table of contents with page numbers? (Chapters should be paginated consecutively, i.e. Chap. 1 (pp. 1-20), Chap. 2 (pp. 21-28), Chap. 3 (pp. 29-44), etc. to allow for modular updates.) |
| Yes | 4. Are the tables and figures clearly labeled and understandable? |
| Yes | 5. Is the protocol bound so that it lies flat, preferably in a 3-ring binder? |
| Section 1 | A. Background and Objectives (Chapter 1) |
| Yes | 1. Does the protocol narrative provide a rationale or justification for why a particular resource or resource issue was selected for monitoring? Is the history and background for this resource issue well-referenced with supporting literature cited? |
| Yes | 2. Does the protocol narrative discuss the linkages between this and other monitoring projects?<br>--Monitoring NSO in Marin County<br>--Sudden Oak Death |
| Yes | 3. Does the protocol narrative describe how monitoring results will inform management decisions? |
| Yes | 4. Does the protocol narrative contain careful documentation of the monitoring objectives or monitoring questions being asked? |
| No | 5. Does the protocol narrative identify specific measurable objectives such as thresholds or trigger points for management actions? |
| Section 1 | B. Sampling Design (Chapter 2) |
| Unclear | 1. Is there a clear and logical rationale for selecting the sampling design over others? |
| Yes | 2a. Were the criteria for site selection clearly discussed including stratification, spatial design, and whether this monitoring will be co-located and/or integrated with other VS monitoring protocols? (See Checklist, Section 1A2.) |
| Yes, but questionable | 2b. Has the target population or "sampling frame", and the sampling units, been identified? In other words, is the desired level of inference clear? |
| Yes | 3. Is the sampling frequency and replication identified? |
| Yes | 4. Is the timing of sampling defined? |
| No, but | 5. Are the location of sampling sites clearly identified? |

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| justified | |
| Yes | 6. Is the level of change that can be detected for the amount or type of sampling being instituted identified? (See Checklist, Section 1A5.) |
| Section 1 | C. Field Methods (Chapter 3) |
| Yes | 1. Are preparations for the field season and equipment setup included? Are requirements for permitting and compliance discussed? |
| Yes | 2. Does the protocol include clear and detailed information on taking measurements with example survey forms included? (Protocol variables and measurements may be discussed in detail in a SOP. A complete set of forms should be included in either the supplementary materials or a SOP.) |
| Yes | 3. Is the method of access for sampling sites provided? |
| N.A. | 4. Is there an overview of procedures for establishing, monumenting, and maintenance of plots discussed in one or more SOPs? |
| N.A. | 5. Does the protocol include details for the post-collection processing of samples or vouchers? |
| Yes | 6. Does the protocol include procedures to be followed at the end of the field season? |
| Section 1 | D. Data Handling, Analysis and Reporting (Chapter 4) |
| Yes | 1. Does the protocol provide an *overview* of the process for entering, editing, and storing data, identification of database software, and whether the database is consistent with the recommended I&M database template structure? (For water quality protocols, see specific water quality guidance in Part B or WRD's General Comments 15, and checklist items in Section 2, items 8-10, below.) |
| N.A. | 2. Are quality assurance (QA) and quality control (QC) procedures presented for the various levels of data collection and analysis? (See water quality Part B guidance or General Comments 15 as appropriate.) |
| Yes | 3. Is the data structure clearly presented and sufficient to capture the required information to meet the stated goal? Is there an overview of the database design? |
| Yes | 4. Are there recommendations for routine data summaries and statistical analysis to detect change? |
| Yes | 5. Is there a recommended reporting schedule?<br>--the word "style" is misspelled (stayle) in Reporting Section 4.5 |
| Yes | 6. Is there a recommended report format with examples of summary tables and figures? |
| In part | 7. Is there a recommendation for long-term trend analysis (e.g. every 5 or 10 years)? |
| Yes | 8. Does the protocol narrative include an adequate description of metadata and data archival procedures? |
| Yes | 9. Does the protocol narrative describe the frequency of testing and review of protocol effectiveness? |
| Section 1 | E. Personnel Requirements and Training (Chapter 5) |
| mostly | Does the narrative include a listing of the personnel and describe their roles and responsibilities, and qualifications?<br>--The Network used outside experts to develop the analytical parts of the protocol. Expertise for population trends reporting is not defined. |

| | |
|---|---|
| Yes | 2. Does the protocol include a discussion of training procedures for personnel? |
| Section 1 | F. Operational Requirements (Chapter 6) |
| Yes | 1. Are facility, vehicle and equipment needs identified? |
| Probably n/a | 2. Is there a summary of key partnerships with agencies, organizations and individuals that are part of the monitoring program and a description of their contribution? Is there a list of relevant cooperative agreements and other partnership agreements, if applicable? |
| Yes | 3. Is a schedule for the annual fieldwork and administrative needs required to implement this protocol included? |
| Yes | 4. Is there an overall budget that summarizes the annual and periodic costs of implementation of the protocol? Does it seem reasonable? |
| mostly | 5. Does the staffing plan and budget demonstrate that adequate resources have been allocated to data management, analysis, and reporting activities (ca. 30% are recommended)?<br>Only 1-2 pp allocated to Wildlife Ecologist; may be insufficient. |
| Section 1 | G. Literature Cited (Chapter 7) |
| Yes | 1. Are the literature citations relevant, sufficient and consistently formatted? |
| Section 2 | Standard Operating Procedures (Selected essential SOPs in addition to those mentioned in the narrative outline are identified in the checklist below. For Water Quality protocols, Part B Guidance or WRD's General Comments 15 should be consulted when developing SOPs.) |
| Yes | 1. Is there a table of contents for the SOPs? |
| Yes | 2. Are changes to each SOP clearly identified with a title, version number **or** revision date, and page numbers? Changes to protocol modules (Chapters or SOPs) should be reflected in the overall protocol version number and protocol revision history log either through a minor or major revision; however, you may also wish to develop a numbering scheme for SOPs, e.g. SOP 1.00, 1.01… |
| Yes | 3. Is there a SOP with instructions for revising the protocol and a revision history log? |
| Yes | 4. Is there a SOP with instructions for preparation before the field season? Is there a SOP with instructions for procedures and equipment storage during and after the field season? (Also see numbers 10 and 11 below.) |
| Yes | 5. Is there a SOP for training field personnel? |
| Yes | 6. Is there a SOP that clearly defines protocol variables and how to measure them? (See Checklist, Section 1C2.) |
| | 7. Are there clear and detailed driving and other navigational instructions to sampling sites? |
| Yes | 8. Are the details of Data Management identified in one or more SOPs? Topics to be included are at minimum identified in Section 1D and may include customized data management routines. Specifically for water quality monitoring data, does the SOP specify how data will be reported to WRD for entry into the Environmental Protection Agency's STORET database? |
| NA | 9. For water quality monitoring and other monitoring as appropriate, is there a quality control SOP associated with each protocol that adequately documents QC objectives for measurement sensitivity (detection limits), measurement precision, measurement systematic error (bias as percent recovery), data |

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|---|---|
| | completeness (including adequacy of planned sample sizes and statistical power – this topic may be in the SOP on Sampling Design), and (if applicable for lab measurements only) blank control? Are instrument calibration details included either in the QC SOP or in a separate calibration SOP? |
| NA | 10. For water quality protocols, is there a SOP that includes an explanation of how data comparability (a quality assurance basic) was considered in choosing which protocols and chemical labs to utilize? Do protocol SOPs contain enough field and lab method details to allow others to determine if data produced is comparable enough to other regional data sets to be considered credible by regulatory agencies interested in the data? |
| NA | 11. Do aquatic protocol SOPs adequately describe the details of all Sampling Protocols (Field and Laboratory), as well as equipment needs and operation, sampling techniques, sample preservation and handling and logistics? |
| Yes | 12. Are all major procedures required for the protocol sufficiently explained? Are any SOPs missing? |
| Yes | 13. Are the literature citations with the SOP relevant, sufficient and consistently formatted? |
| Section 3 | Supplementary Materials or Appendices |
| NA | 1. Is there a table of contents with Section 3 – Supplementary Materials that clearly identifies the materials provided in this section of the protocol? |
| NA | 2. Are the supplementary materials relevant, sufficient and consistently presented? Consistent formatting is desirable, but not always possible. |
| Yes | 3. Are data collection forms provided either in this section or in an SOP? |
| Yes | 4. Is there a section for the Administrative Record that provides the history of protocol development and refinement? A summary event table is highly recommended in addition to the supporting materials required in the Protocol Review File Checklist, e.g. the initial study plan or protocol development summary, the results of protocol development studies, peer review comments and responses during the development phase, and/or any published protocol on which a major portion of the methodology included in this protocol is based. (The published protocol may be presented either in Section 2 or Section 3 depending upon its contribution to the current protocol.) |

PRC (Agee) Comments

This is a well-written and concise protocol. Specific comments by page number, paragraph, and line number:

Xiii, par 1 l 6: the owl is threatened, not endangered (as noted page 1 line 1).

*Fixed*.

P3, par 3. If there were 80 known sites before state and county lands were added, why did not that number increase when the other lands were added (Patti Happe made same comments in earlier draft).

*The 1997-1998 inventories included NPS and adjacent lands, including Marin Municipal Water District, Marin County Open Space, and California State Parks. The inventory identified at least 80 different NSO activity sites throughout Marin County. The 80 sites were not just on federal lands. The paragraph noted has been revised to be clearer*.

P6, par 2, l 7: If the Stralberg analysis was done in 1999-2002, how is it not published 6 years later?

*Stralberg's habitat model was published in 2009. The full citation is noted here and has been updated in the Literature Cited section of the protocol*.

*Stralberg, D., K. E. Fehring, N. Nur, L. Y. Pomara, D. B. Adams, D. Hatch, G. R. Geupel, and S. Allen. 2009. Modeling nest-site occurrence for the Northern Spotted Owl at its southern range limit in central California. Landscape and Urban Planning 90:76-85*.

P8, par 2, l 3 from bottom. If tanoak represents one species, how can its loss represent a "substantial proportion" of tree species richness (defined as number of species)?

*Average species richness was low in the plots studied for Sudden Oak Death. In redwood forests, for example, average tree species richness was 3.2, which included tanoak. The authors wrote:*

*"Tanoak represents a substantial proportion of tree species richness and total woody species richness in both redwood and Douglas-fir forests. In our redwood plots, which are species-poor in comparison to our Douglas-fir plots, tanoak accounts for an average of one third of tree species richness and one fifth of total woody species richness. If tanoak is eventually eliminated by SOD, the species richness of redwood forests will be severely reduced."*

*We have modified the section referenced (page 8, paragraph 2) to more accurately reflect the study's findings.*

P9, par 4 (Mgt objectives). Given the comments of two reviewers, I question that NSO monitoring will actually provide "critical data for land managers".

*The sentence is in reference to the annual needs that park managers have for NSO data in order to perform regular park operations and maintenance. Consultation with NSO biologists has become a routine element when planning for fuel reduction projects, trail re-routes, and law enforcement actions. In this sense, the NSO monitoring data has proven itself to be a critical planning tool year after year. We hope that with revisions to our sampling design the SPOW data will prove equally as critical in determining the long-term trends in the status of the species in the parks.*

P26, par 2, l 7: comparison, not comparision

*Fixed*.

P 26, last par, l 6: Style not Stayle

*Fixed*.

SFAN Spotted Owl Reviewer #1.

## Process of Vial Signs Protocol Review: Summary

*San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol v6.3*

### Background and Objectives

A good background of previous work was presented. The protocol represents significant work and thought. However, I am concerned that the objectives of the protocol will not meet the objectives of the Vital Signs monitoring. Some specific objectives were presented. The objectives of the protocol are limited to addressing long-term trends in occupancy and reproduction of a subset of documented "activity sites". It seems improbable that there will be timely information to inform managers about emerging problems. There are no firm monitoring plans for the threats that seem most imminent: increasing barred owls and declining forest health due to sudden oak death. The objectives and the rest of the protocol seem excessively bounded by lack of funds and personnel. Even if a decline is noted, the reasons for the decline in spotted owls will be obscure.

### Sampling Design

The sample design is limited by funding and personnel. I am concerned that the selection of 20-25 permanent monitoring sites results in a too narrow sample and that will not allow inferences to be drawn without pseudo-replication. Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon. The 3 years on/3years off sampling is efficient in terms of cost:benefit ratios, but very inefficient in timely detection of changes.

### Sampling Methods

Methods are well described and based on a power analysis, for number of visits. But I am concerned that the number of visits is still too low (3) to establish no occupancy, particularly with increasing barred owl presence. Establishing occupancy is easy (you see one and it's occupied), reproduction is more time consuming, but vacancy (proving a negative) is the most difficult.

It is not clear if the detailed measurements around nest trees will help meet overall objectives or if they will prove redundant.

### Analytical Techniques

The analytical techniques are well developed and adequate given the design. As stated above, statistical rigor was used in developing sampling frequency using power analyses. Long-term trend analysis (5-10 yr) will be problematic with a 3yr on/3yr off design.

R1 Specific Comments

p. xiii: threats: put in order of importance; habitat loss due to anthropogenic and natural causes is probably number 1 (if within this broad category a more specific threat is paramount it should be identified; e.g., wildfire), barred owl is probably number 2, human disturbance is probably number 3. Is there any local data on sudden oak death? Other introduced plant diseases? WNV? How about other mosquito-borne diseases (e.g., the equine encephalitis group of arboviruses, avian malarias, etc.)? My concern here is that real threats be identified, new potential threats be identified along with some likelihood, etc. and not just a "bandwagon" list of threats. My concern goes beyond the bandwagon idea: we are likely going to experience a variety of new threats due to introduction of pests and diseases and exacerbation of endemic pests and diseases due to climate and land-use changes.

> *The sentence has been re-arranged, but we do not believe, nor do we suggest, that the list of potential threats is complete or that it represents the order of importance. At this point, we do not have enough information to accurately place these threats in order of importance. We consider all of these as real threats until proven otherwise. More detail on threats is provided in the protocol narrative, specifically in section 1.4.*

The objectives apply to "activity sites" suggesting a limited subset of already identified locations available in the sampling universe within the legislated NPS boundaries will be monitored; the evaluation of changes in nesting "habitat" (there is no such thing as nesting habitat; there is habitat, and there are nest sites) within the boundaries is a non-sequitur if sampling is limited to existing activity sites.

> *We have modified our use of the terms "territory" and "activity site" within our monitoring objectives and throughout the remainder of the protocol and SOPs. We will be monitoring occupancy and fecundity of NSO territories. All known territories within the study area have been identified through exhaustive inventory efforts. Each year, surveys are focused on the activity site, or activity center, within each territory. The activity site is defined as the area occupied during a single breeding season by a territorial NSO resident single or pair, which would include a nest and/or roost site. Activity sites may, or may not, change from year to year.*

Page 1, line 1: what was the reason for listing?

> *Sentence revised to read: Northern spotted owls (Strix occidentalis caurina: NSO) were listed as federally threatened by the U.S. Fish and Wildlife Service on June 22, 1990 "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990).*

Page 3, 1.2.2: what was the basis for the choice of the 46 of the 80 known activity sites?

> *As noted on pg. 5, par. 2, the 46 sites were based on accessibility, management issues, and forest type. The selection was non-random, leading the NPS to modify its sampling*

*design during the course of developing this protocol. The selection criteria of the 46 sites have been moved to page 3, section 1.2.2.*

Owls habituated to food may be less vulnerable to disturbance by park visitors and recreationists and other people because they are habituated—the presence of people is no longer novel or threatening. Mousing/habituation could also reduce the stress of repeated playback/imitated calls during surveys. Foster et al. found negative effects of research on owls they attributed to radios, but which could have as easily been attributed to repeated calling, capture, and handling for banding and for attaching radios as to the radio itself—improper attachment leading to injury to the owl, especially sores and lacerations is, of course, very serious (Foster, C. C., E. D. Forsman, E. C. Meslow, G. S. Miller, J. A. Reid, F. F. Wagner, A. B. Carey, and J. B. Lint. 1992 . Survival and reproduction of radio-marked adult spotted owls. Journal of Wildlife Management 56(1): 91-95). In my talks with Forsman, he has often discounted the negative impacts of normal forest operations (from maintenance to recreation) on owls and cites the case of an owl nest in a spar tree in a logging operation. Habituation can be a good thing.

*The SFAN protocol limits the amount of mousing to the bare minimum needed to successfully determine occupancy and reproductive status. Mousing is used as a last resort only. Our approach to mousing and our concern for habituating a listed T&E species is consistent with NPS management policies. We have no intention of modifying our approach to mousing. In a response letter to the SFAN (Appendix SOP 7D), reviewer 4 wrote that in regards to mousing, "We don't have any concerns with the consistency of SFAN methods."*

Page 5: dismiss the protocol as a measurable effect because other sites also used same protocol?

*In the sentence referenced, "fluctuations" has been modified to read "annual fluctuations in fecundity". We simply noted that during the demography study we observed fluctuations similar to other CA study sites, leading us to believe that our modified monitoring protocol did not have a measurable effect on fecundity determinations.*

Paragraph 2 suggests highly biased sampling.

*We agree and modified our site selection accordingly following our 2006 inventory. See next paragraph in narrative.*

Paragraph 3 is circular: habitat is *defined* as the space(s) occupied by the species. Growth in occupancy must follow growth in habitat space. Yes, of course, there is some fluctuation around carrying capacity due to random demographic and environmental (e.g., weather) effects.

*In the paragraph, we use the term "suitable habitat", meaning the forested areas within the park boundaries where we would expect spotted owls to occur. The reviewer is correct that occupancy must follow growth in habitat space, but only if occupancy is already at carrying capacity. We simply noted a previous reviewer's concerns that we are at carrying capacity, making occupancy growth impossible to measure.*

1.3.1. I suggest rigorous use of terminology. When using "habitat" use it to refer to the areas actually occupied by spotted owls or the types of areas routinely occupied by owls. Use other language (forest types, forest seral stages, plant community classification, etc. such as provided in Wildlife-Habitat relationships manuals) when referring to the biotic environment in a more general way.

Old-growth and mature forests is a particularly annoying combination of terms. What is mature: generally when trees reach their asymptotic height or when they become economically "mature". You can just say older forest or late-seral stage forest, etc. Similarly "multi-storied structure and high canopy cover" is over-used. You could say botanically diverse forests with complex structure and be more accurate and more descriptive.

We should be moving away from jargon and shibboleths if we want to advance our understanding of animal-environment relationships.

I'll skip further comments on language and terminology as it could get tedious.

> *Our use of terminology is consistent with that in the published NSO literature. Some minor changes were made throughout the protocol as suggested.*

Page 7, 1.4, 1st sentence; yes, well written, and should be place up front in any discussion of threats. Nice discussion in this section.

Page 8, line 1 suggests that BAOW are now the major potential threat within the area to be monitored? The next paragraph documents a major forest health problem with SOD. Does this also create increased fire danger? Any quantitative information on effects on prey base? Might this be a threat that has to be monitored?

> *Oak mortality induced by SOD likely causes changes in fuel loading, stand structure, and microclimate. As these changes occur, the potential for uncharacteristically extreme fire behavior and associated ecological impacts may increase. Anecdotal reports from fire fighters working in redwood forests infested with SOD during the 2008 Basin Fire in Big Sur, California indicated increases in fire intensity of approximately 25% (Lee et al. 2009).*
>
> *We are not aware of any quantitative studies in the published literature that have investigated the effects of SOD on NSO prey base. However, PORE has submitted a grant request to USDA to research effects of SOD on NSO, including prey base.*
>
> *We have added an additional component to our field methods that establishes a SOD severity rating at each activity center identified during our monitoring efforts. Please refer to Section 3.4.2 of the protocol narrative and Section 6.3.2 in SOP 2: Standard Field Methods.*

1.5: Would it not be necessary to include BAOW and SOD in your objectives given the massive potential for impacts on owls? Again it is not clear if only existing activity sites are being monitored or if new activity sites can be recruited.

> *Measures of barred owl populations or SOD as causal factors for changes in spotted owl populations is beyond the scope of this monitoring protocol. In a response letter to the SFAN (Appendix SOP 7D), Dr. Agee, the PWR Protocol Review Coordinator, wrote, "As these are likely research topics, they should not be required as part of a monitoring protocol."*
>
> *As mentioned, we have added a severity rating for SOD occurrence at activity centers to our field methods. Focused efforts beyond the incidental detections of barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Rather than add extensive monitoring of BAOW and SOD to the NSO protocol, we propose to use these simple measures of BAOW and SOD presence as covariates when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starcevich and Steinhorst (2010). See SOP 5: Data Analysis and Reporting for details.*
>
> *We anticipate that additional SOD data sources within the study area will become available over time from other research projects. For example, in 2010, PORE submitted a USDA grant proposal to quantify the potential impacts of SOD on northern spotted owls within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests.*
>
> *All known territories within the study area were identified during inventory efforts in 1997-1998 and 2006. A few areas with suitable habitat but where NSO were not detected may be re-inventoried as time allows. Newly discovered territories will be added into the sampling design.*

Page 9.Para 1: I don't believe owl demographic data can be used to accurately assess status and trend in the short- to medium term unless there is understanding of the factors underlying the demography. Nest-site characteristics may prove less important than foraging area characteristics.

> *Status and trends in NSO occupancy and fecundity can be assessed given our proposed sample design, as outlined in Section 2.0 Sample Design. The reviewer is correct, however, that the protocol may not have the ability to identify the underlying factors resulting in significant changes to occupancy and fecundity. The NSO monitoring program is unfortunately unable to collect meaningful data on all factors that may influence the NSO population within the study area. In a response letter to the SFAN (Appendix SOP 7D), reviewer 4 wrote, "My understanding is that vital signs monitoring is to detect change, and if change is detected, we are to do targeted research to understand what is going on. Monitoring foraging habitat and prey base is way beyond what the program is supposed to do."*

*We propose to collect information on nest site characteristics, activity center Sudden Oak Death presence and severity, and barred owl presence within the territories that are monitored. These factors may prove valuable in determining the cause of declines in occupancy and fecundity and will not tax the program with extensive, additional data collection. In addition, the SFAN has access to a broad range of additional abiotic and biotic data sources which may be employed when trying to understand long-term trends in the NSO data. For example, weather and climate data, both local and regional, are readily accessible. In addition, we have outlined in SOP 5: Data Analysis and Reporting our approach to NSO habitat modeling within the study area using nest site measurements and a suite of available landscape variables. On a final note, NSO monitoring may identify future, critical research needs, such as woodrat density, to help explain trends in the data.*

Lack of funding may preclude effective monitoring and evaluation if the methods chosen deviated markedly from the more widespread use of more intensive methods—you lose the ability for comparing local demographic performance to regional and universal performance.

*Without the ability to fund a rigorous banding program, our monitoring efforts are less intensive than the demography monitoring areas within the northern spotted owl's range. However, our occupancy and fecundity methods and data are comparable and could be compared at regional and range-wide spatial scales. For example, data from our study area was incorporated into Anthony et al. (2006) which analyzed demographic data from 14 study areas in Washington, Oregon, and California for the time period of 1985–2003.*

*Data from our monitoring effort will also contribute towards Recovery Action 3, to conduct occupancy inventory or predictive modeling, of the NSO Recovery Plan (USFWS 2008). The recovery plan notes, "Periodic assessment of the distribution of spotted owls is important because the demographic study areas may not be representative of range-wide conditions."*

1.6. para 1: so at least 1 purpose of the monitoring is to keep people away from active nest sites?

*Yes – this is an important management objective of the program.*

The presence of BAOW is not only a potential threat to SPOW but also may affect the efficacy of monitoring of SPOW; SPOW may become harder to detect in the presence of BAOW. It may be necessary to make provision for some additional methods if BAOW increasingly respond to SPOW playback calls.

*Spotted owl detections within the presence of barred owls is a difficult issue faced by all agencies monitoring spotted owls range-wide. While the reviewer is correct that we may need to make provisions for additional methods to monitor spotted owls as our barred owl population increases, we will seek guidance in this matter to ensure that new methods are compatible with range-wide recommendations.*

*The USFWS released the draft "2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls" (USFWS 2010) in February 2010. The revised protocol addresses the effectiveness of the USFWS 1992 survey protocol, particularly those surveys which do not result in spotted owl detections, most likely due to barred owl presence. Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.*

Page 10, 1.7: trigger points not identified—therefore no planned response to changes in owl populations? Kind of abrogates the need for monitoring. If causes of declines can be determined … that is not built into the monitoring. The failure to obtain funding for BAOW and SOD studies may very undercut the value of any SPOW monitoring.

*Management triggers have been identified and added to the protocol under Section 1.7. Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol. In some cases, causes of declines in the NSO population, such as barred owls, may be easy to identify. In other cases, however, additional, specific research may be required. Depending on the management action(s), the NEPA process may be instigated, requiring significant public input. Although the SFAN will provide data and guidance, management actions will ultimately be decided by PORE, GOGA, and MUWO management staff, including, but not limited to, the park Wildlife Biologists, Science Advisors, Chiefs of Resource Management, and Superintendents.*

*Measures of barred owl populations or sudden oak death as causal factors for changes in spotted owl populations is beyond the scope of this monitoring protocol. In a response letter to the SFAN (Appendix SOP 7D), Dr. Agee, the PWR Protocol Review Coordinator, wrote, "As these are likely research topics, they should not be required as part of a monitoring protocol." As previously explained, however, barred owl and SOD data can be used as covariates in our long-term trend analyses.*

Page 12, 2.1: One has to wonder that with 3 years on and 3years off, what might actually be gained by monitoring other than documenting population stability or population collapse … would there be opportunity for management intervention at all?

*During revisions of this protocol, we developed new occupancy and fecundity power analyses under contract with the University of Idaho (Starcevich and Steinhorst 2010), which is included in the protocol as Appendix A. Starcevich and Steinhorst (2010) reviewed the power to detect trends for a variety of sample sizes and re-visit designs. The resulting sample design that we propose to implement is detailed in Section 2.0 of the protocol narrative. The SFAN will not implement a 3 years on 3 years off monitoring design.*

Page 2.3.1.: By choosing a limited set of permanent sites have you limited your inference to these sites and these sites alone? In other words, you have one unique sample that you will study repeatedly, allowing no inference to other areas beyond the 1st sample in time, and allowing no calculation of error without using pseudo-replication.

*Our revised sample design overcomes the short comings of the previous sample design noted by the reviewer. We propose an annual panel of 28 sites and four rotating of panels of 8 sites each. A total of 36 sites will be monitored each year. Over a four year period, all territories within the study area will be surveyed.*

Page 14, Para 2: increasing presence of BAOW may change these probabilities. I assume you are limiting samples to days without unusual weather or disturbances. No or low breeding obviously changes these probabilities; don't you have to assume some no/low breeding years and a priori adjust effort? 1 detection is sufficient; 3 failure to detect might well be insufficient.

*The SFAN must re-visit the NSO detection rate within the study area on a regular basis to ensure that the monitoring design it still capable of meeting the monitoring objectives. We expect to review the entire monitoring design, which incorporates the detection rate, approximately every 5 years when trend reports are prepared. Conditions in the field, such as a significant increase in barred owl detections, may warrant more immediate evaluation of the monitoring design.*

*The USFWS released the draft "2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls" (USFWS 2010) in February 2010. The revised protocol addresses the effectiveness of the USFWS 1992 survey protocol, particularly those surveys which do not result in spotted owl detections, most likely due to barred owl presence. Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.*

Page 15, 2.5.: accepting an increased likelihood to detect catastrophic decline is perhaps a fatal flaw in this plan, if, as stated, monitoring results are to be feedback to management.

*Our revised sample design has more than the ability to simply detect catastrophic declines. The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater. See Section 2.0 Sampling Design for details.*

Page 19, 3.1: Will new survey members be formally "certified" as competent (or not) by trusted, experienced staff during field familiarization?

*With a limited budget and staff, monitoring efforts would lose significant ground if a newly hired survey member proves to be incompetent in the field. However, even with rigorous hiring procedures and thorough reference checks, the SFAN may inadvertently hire someone that is inadequate in the field. New hires will undergo significant training and thorough review of field notes, datasheets, and maps. New staff will not be permitted* *to conduct solo surveys until supervisory staff is confident in their abilities. If a new hire proves incompetent, the SFAN staff will be forced to fill in as needed until an adequate replacement arrives. Training requirements for new staff have been added in a new section of SOP 1.*

Page 20: What provision is there for field observers to report any problems or doubts they have about the protocol so that these can be addressed immediately?

*While there is no formal method for reporting problems outlined in the protocol, our staff is small, works together very closely during the field season, and checks-in almost daily. Field observers are traditionally supervised by others that are actively participating in the monitoring. The staff holds a pre-season, organizational meeting, and there are several follow-ups during the course of the season, both via email and during face-to-face meetings. Field observers are always encouraged to report problems or doubts regarding their work.*

3.3.2. To what use will these detailed measurement of nest trees be put? It doesn't seem to address the monitoring objectives.

*Nest site measurements directly address monitoring objective 3. Other studies have detailed similar nest characteristics (i.e., Buchanan and Irwin 1993). Nest site measurements are very simple to conduct in the field with virtually no extra cost to the field crew. They also provide us with good indications of major changes in nest site selection and habitat around the nest sites. Some nest site variables may be incorporated into modeling approaches to assess NSO habitat relationships within the study area.*

Page 21, 3.4.1: are there other diseases as likely or more likely to affect the owls, such as those in the equine encephalitis group?

*Unknown. The NSO Recovery Plan (USFWS 2008) indicates that, "At this time, no avian diseases are significantly affecting spotted owls. It is unknown whether avian diseases such as West Nile Virus (WNV) or avian flu will significantly affect spotted owls."*

3.4.2: I would think a more careful reporting for SOD would be employed; all SOD could be GPS'd and reported.

*SOD is widespread throughout much of the NSO study area. A GPS point of all SOD occurrences would take away from much of the limited field time available for NSO monitoring. An independent effort to develop GIS layers of SOD presence and severity is a more suitable approach. The NPS submitted a proposal to USDA in 2010 to develop these GIS layers as part of an SOD research project. In addition, a SOD Severity Index has been added to the protocol that will provide an assessment of SOD around NSO activity centers.*

Page 29: certification procedures for biotechs and volunteers should be developed.

*Although no formal certification procedures exist, training requirements for volunteers and new staff are outlined in SOP 1.*

SOP 2, Page 24: define overstory and understory very specifically. 33% by cover? By Biomass? Count overstory foliage in the understory as in the understory. Be very specific.

*We have added specific details to this section, including clarification that we are recording species that compose >33% by cover. Overstory classification assumes that a tree receives direct sunlight, and thus its loss will increase light penetration to the forest floor. Understory vegetation may occur at any height secondary to the upper canopy layer, and includes secondary trees, shrubs, and herbs.*

SOP 2, Page 25: description of site is too vaguely worded, too subject to interobserver variability.

*This portion of the nest habitat form has no set guidelines. However we have added the following guidance to this section, "Provide all details needed to orient future field staff to the site."*

SOP 5, Page 4: I may have missed it, but all the data collected around nests—how do you avoid duplicate measurements or do you intend them? I'm confused about how you value "trends" in slope, distance to opening, distance to edge, water, etc.

*During the course of this study, we have documented owls re-using nest trees, sometimes even the same platform or cavity nest structure. As of 2008, of the 274 nests located, approximately 12% of those were re-used nest trees. For each year that a nest tree is used, we re- measure nest tree DBH, nest height, slope, aspect, distance to water, etc. at the nest tree. During analysis, it will be easy to filter the data for nest trees used in more than one year and avoid adding duplicate measurements into the analysis.*

*A suite of habitat variables will be employed to evaluate NSO habitat relationships within the study area over time. Some measures will be collected on site whereas others will be based on available GIS layers. If models that predict NSO nest site occurrence or reproductive success shift over time, the data can be further explored to see what habitat variables are driving model variances. For example, we could explore an interaction between year and distance to edge to see if there has been a significant movement of NSO towards forest edge habitats over time. The root cause of such a shift, however, may not be explained by the data and could require additional research.*

Nice Job Hazard Analysis.

SFAN Spotted Owl Reviewer #2

The three reviewers who reviewed an earlier version of this protocol in 2004 affirmed many of the checklist items. I agree with those assessments and did not cover them in this review. Key comments made by 2004 reviewer R. J. Gutiérrez are referenced below as *RJG*.

1. Is the overall monitoring protocol well organized, clearly written and will it produce scientifically sound results?

RJG stated that *the basic protocol is fine,* which I agree, but he also stated that *the details of analysis are sufficiently unclear to allow answering the question will it produce "scientifically sound results?" The key issues are the randomization design for the sampling and the explicit analysis to be used for different types of data gathered.* The randomized design issue was addressed by the authors. Analyses to assess long term trends are too hypothetical. It's still unclear if the monitoring data are capable of delivering statistically significant trends. While the analytical methods for occupancy rate and fecundity are described briefly in SOP 5, it seems that the details of the methods are in an unpublished report by Connor and LeBuhn 2007. In SOP 5, the analytical methods are not linked back to the sampling design to demonstrate that detecting trends are feasible in such small landscapes. Also, the Narrative needs to succulently describe the analyses used to assess long-term trends.

> *During revisions of this protocol, we developed new occupancy and fecundity power analyses under contract with the University of Idaho (Starcevich and Steinhorst 2010), which is included in the protocol as Appendix A. Starcevich and Steinhorst (2010) reviewed the power to detect trends for a variety of sample sizes and re-visit designs. The resulting sample design that we propose to implement is detailed in Section 2.0 of the protocol narrative. The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater. Our methods for long-term occupancy and fecundity analyses are entirely derived from Starcevich and Steinhorst (2010) and are described in SOP 5: Data Analysis and Reporting.*

It is not clear how the authors are addressing <u>long-term effects of barred owls</u> relative to the listed three measureable objectives in the Narrative.

Narrative 2.1: *Occupancy monitoring, when combined with detection probabilities, may be the most cost-effective means to detect population trends, <u>long-term effects of barred owls</u>, or other threats to the NSO population on federal lands in Marin County.*

*Olson et al. (2005) recommend the use of a site-specific barred owl covariate in NSO detectability analyses to prevent false conclusions about NSO occupancy decreases.*

Issues surrounding the sampling of Barred Owls need to be addressed.

> *A systematic protocol for sampling barred owl occupancy within the study area is beyond the scope of this monitoring protocol. Focused efforts beyond the incidental detections of*

*barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Our approach instead will be to use BAOW as a covariate when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starcevich and Steinhorst (2010). SOP 5: Data Analysis and Reporting details our approach to incorporating barred owls presence into occupancy, fecundity, and habitat analyses.*

5. Does the monitoring protocol include a good and thorough summary of existing and previous monitoring work in the parks, the network of parks, and region relative to the indicator

Key research/monitoring findings on spotted owls in CA and from the broader perspective--Anthony et al. 2006--needs to be included (providing a range-wide context for work in Marin County).

*Section 1.1 has been re-organized and re-titled as "Northern Spotted Owl Range-Wide Status and Habitat Associations". The rationale for monitoring initially contained in Section 1.1 has been expanded and moved to just before Section 1.1. A summary of key research findings from the NSO literature, including Anthony et al. 2006, has been included in Section 1.1.*

7. Does the monitoring protocol include clear and specific objectives for management action such as thresholds and or trends?

The authors acknowledge that *trigger points for management have not been identified.* Not clear what management can do. Removal of barred owls from national parks is not a viable option.

*Management triggers have been identified and added to the protocol under Section 1.7. Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol.*

4. Is the sampling and experimental design appropriate and sufficient to answer the monitoring questions and ensure statistical validity?

Details are missing for long-term analyses and habitat relations.

*Detailed statistical methods for detecting changes in occupancy and fecundity over time have been added to SOP 5: Data Analysis and Reporting. We have also drafted a detailed GIS modeling approach that will be used to investigate how occupancy and reproductive success may be related to important habitat variables.*

1. Is planning and project management (e.g., staffing, budgeting, scheduling) clearly described, logical, and likely to ensure that the project objectives will be met?

Budget/staffing time commitment for analyses and reports not clear.

*Annual reporting is built into the annual project schedule as indicated in Table 3. The Lead Biological Technician is responsible for report preparation in coordination with the project lead(s), as indicated in Section 4.5 and Section 5.1. We have added to Section 6.3 to clarify that the annual budget for the Lead Biological Technician includes completion of the annual report. Section 5.1 clarifies that long-term trend reports are initiated and completed by the project lead(s). Budget needs for long-term trend reports are unknown at this time. However, Section 6.3 states, "If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports."*

7. Does the plan discuss the need for periodic reviews of the overall monitoring program as well as individual protocols or other components?

*Protocol revisions are discussed in several places in the protocol narrative and SOPs. Section 2.4 of the protocol narrative discusses the need to periodically review the effectiveness of the NSO monitoring design to detect target trends in occupancy and fecundity in a timely manner. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. Section 4.6 and SOP 5: Data Analysis and Reporting note that a review of the sampling design, field methods, and analytical techniques will be explored in detail as a component of the long-term trend reports produced every 5 years. Finally, SOP 7: Revising the Protocol addresses the need to revise methodologies for collecting and analyzing monitoring data as new information becomes available. The SOP provides detailed instructions on protocol revisions to ensure that edits are reviewed, well-documented, and that current protocol versions are adequately distributed.*

1. Are the literature citations relevant, sufficient and consistently formatted?

A succinct, broader literature review is needed of the NSO, especially (1) habitat studies that might guide objective 3 and (2) summarize 2006 Anthony et al. results.

*Section 1.1 has been re-organized and re-titled as "Northern Spotted Owl Range-Wide Status and Habitat Associations". The rationale for monitoring initially contained in Section 1.1 has been expanded and moved to just before Section 1.1. A summary of key research findings from the NSO literature, including Anthony et al. 2006, has been included in Section 1.1. Section 1.3.1 has been expanded and discusses research on NSO habitat relationships within the I&M study area.*

2. Does the literature reflect current scientific understanding of the target indicator(s)?

Agree with RJG's 2004 comment: *Was insufficient to determine this.*

*Relevant citations from the scientific literature have been expanded.*

Additional comments and suggestions:

**A. Sample Design**

The protocol appears sufficient to "generally" inform managers from San Francisco Network National Parks about the status and trends of the NSO breeding in these Parks. For this species, high-profile and threatened, the NPS needs to be extraordinarily careful in developing a protocol that will stand up in the courts. The reality is that the NSO is among the most litigated species in North America. The context surrounding the NSO, unfortunately, raises the bar for developing a monitoring protocol--beyond simply informing status and trends to managers that have few, if any options to take management actions for this species.

It is plausible that NSO monitoring results from Marin County National Parks could find its way into court cases. If so, would the trend analyses of occupancy and fecundity rates used in this protocol stand up in court? Statistical inferences that can be drawn from the protocol design/methods seem weak.

The protocol states: *there is a 78% probability in capturing a 10% annual decline over 8 years n=20.*

A 10% annual decline is an extraordinarily steep decline. Detecting this steep decline comes at a moderate probability, too, 78% at alpha=0.2. Any decline less than a very rapid local extinction will not be detected effectively. It seems evident: for this protocol to be effective, the monitoring sample size needs to be increased substantially, perhaps doubled, and the sample frequency needs to be annual rather than periodic. The budget is well below what is needed to monitor this species effectively.

> *Our revised sampling design, presented in Section 2.0 of the protocol narrative, addresses the reviewers concerns. We are proposing to monitor an annual panel of 28 sites for occupancy and fecundity. The remaining 32 sites within the study area are split into four panels of 8 sites each, which will be visited over a four year period. With 8 additional sites monitored each year, we reach a total of 36 sites monitored annually (28 + 8). The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater.*

**B. Barred Owls**

A systematic protocol for reliably sampling Barred Owl occupancy was not presented in the protocol. The following outputs are expected in the protocol using what is assumed to be an opportunistic sampling scheme for Barred Owls:

- *Barred owl*
    - *Number of detections*
    - *Number of NSO sites with barred owls detected*
    - *Barred owl occupancy status at sites*
    - *Estimate of number of barred owls in study area*

*To test for barred owl effects, correlations between number of barred owls on NSO territories can be made with NSO territory occupancy or fecundity. Barred owl presence on a territory could be used as a covariate in a logistic regression analysis of NSO reproductive success. Effects of barred owls could be determined through examining whether barred owl presence is associated with changes in NSO nest site characteristics at different scales (ANOVA).*

> *A systematic protocol for sampling barred owl occupancy within the study area is beyond the scope of this monitoring protocol. Focused efforts beyond the incidental detections of barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Our approach instead will be to use BAOW as a covariate when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starcevich and Steinhorst (2010). See SOP: 5 Data Analysis and Reporting for details.*

**C. Effects of Periodically Changing the Study Design**

The authors suggested that the sample design would have to change as Barred Owl populations increased (inevitable?) (text shown below). Yet, no assessment was given on the effects that drawing new samples would have on future analyses and the ability to detect trends in a reasonable timeframe. If new samples are inevitable, does it make sense to commit a long-term monitoring program to this species?

Narrative 2.3.1: *Sample sites will be permanent, unless there are biological reasons to review the protocol, reassess the sample population, and reselect a sample. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. In addition, a precipitous drop in the occupancy rate may suggest that owls are leaving the study area, moving further outside of their historic activity centers than our field monitoring protocols can capture, or are dying for reasons unknown. Reanalyzing the detection rates using new data, completing a full study area inventory, and revising the field methods are possible responses.*

Narrative 2.5.3: *A random sample that is initially representative of a larger sample population can lose this ability with long-term, large-scale population changes, such as what has been seen in the effects of barred owls on the NSO populations in the Pacific Northwest. While the best sampling design is spatially and temporally balanced enough to reflect these large-scale shifts, in some cases, the shift is not captured. Knowing that the Marin County NSO population has the potential for a large change with an expansion of barred owl numbers, another inventory may be needed to in the near future to avoid the problem of missing such shifts in distribution or abundance of NSO or barred owls. Depending on findings, a new random fecundity and/or occupancy monitoring sample could be selected from this inventoried population, which may avoid any research bias that could develop by surveying the same sample of sites each year.*

> *Our newly proposed sampling design visits all sites within our study area within a 4 year time-frame. A random sample that is not representative of the entire population is no*

*longer an issue with this protocol. The protocol narrative reflects this change, and the second paragraph quoted above has been removed.*

*As with other monitoring protocols, we will still need to review our sample design and field methods on a periodic basis to ensure that we are still able to meet our monitoring objectives. Protocol review will be a component of our long-term trend reports. We have added Section 2.4 Sample Design Review to the protocol narrative which outlines the need to review the sample design and field methods on a periodic basis.*

**D. Inconsistencies**

1. Narrative 4.4: *For the annual reports, only NPS occupancy data from the 25 long-term monitoring sites and NPS fecundity data from the <u>25 fecundity sites</u> are summarized and presented.*

Narrative 2.3.1: *The process was repeated for the fecundity monitoring using the fecundity potential sample population and selecting the first <u>20 sites</u>.*

*This was an unintentional inconsistency in the draft protocol we submitted for review. The error is irrelevant at this point since we have increased our sample size. We will monitor 36 sites each year for occupancy and fecundity. Both sections noted above have been revised to reflect our currently proposed sample design.*

2. Inconsistent when long-term trend reports will be produced:
SOP 5 2.0: every 9-13 years
Narrative 4.6: every 10 years.

*This was an unintentional inconsistency in the draft protocol we submitted for review. With our current proposal of annual monitoring, we now suggest that long-term trend reports should be produced every 5 years.*

**E. Budget**

Narrative 6.2: Not clear from the budget where/how analyses and report production are being funded?

*Annual reporting is built-into the annual project schedule as indicated in Table 3. The Lead Biological Technician is responsible for report preparation in coordination with the project lead(s), as indicated in Section 4.5 and Section 5.1. We have added to Section 6.3 to clarify that the annual budget for the Lead Biological Technician includes completion of the annual report. Section 5.1 clarifies that long-term trend reports are initiated and completed by the project lead(s). Budget needs for long-term trend reports are unknown at this time. However, Section 6.3 states, "If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports."*

## F. Peer Review Reconciliation

Comment from 2004 reviewer RJG: "….need to clarify the style. I would write this as if it were a proposal. We will do this and we will do that style. or this will be done and that will be done by this group in this manner."

Style still needs work.

For example from SOP 5.2: *Some examples of potential analyses are examining differences in occupancy and fecundity rates between age classes of females and males, factors associated with differences in habitat quality, different nesting habitat factors (e.g., distance to water, forest edge, and dominant forest structure).*

> *Improvements to the writing style were made throughout the protocol narrative and accompanying SOPs.*

### Long-term Trend Analysis Reporting

Narrative section 4.6 lacks any explanation of what kind of analyses will be done to determine statistically significant long-term trends. This is the most important analysis of the monitoring project.

> *Detailed statistical methods for detecting changes in occupancy and fecundity over time have been added to SOP 5: Data Analysis and Reporting. We have also drafted a detailed GIS modeling approach that will be used to investigate how occupancy and reproductive success may be related to important habitat variables. The approach to trend detection tiers off of the power analyses performed by Starcevich and Steinhorst (2010) which is described in detail in protocol Section 2.2, Section 2.3, and is included as Appendix A. Protocol Section 4.6 directs readers to the detailed step-by-step guidance to methods for long-term analytical techniques presented in SOP 5.*

# Appendix SOP 7C: December 2008 letter from SFAN to PWR Protocol Review Coordinator.

In December 2008, SFAN and park staff associated with the northern spotted owl monitoring protocol drafted a series of questions and clarifications following the formal peer review comments received in October 2008. A letter was sent to Dr. Jim Agee, PWR Protocol Review Coordinator, via email. The SFAN letter is included below and Dr. Agee's response is included as Appendix SOP 7D.

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12/18/2008

Dear Dr. Agee,

Thank you for the response and comments from yourself and two reviewers on the SFAN Spotted Owl Monitoring Protocol. We greatly appreciate the reviewers' time and their high level of scrutiny. Many of the comments will be relatively easy to address in a subsequent draft. For example, we agree that we made inconsistent use of the term "habitat" and were unclear about the number of sample sites in different sections of the protocol and SOP.

We are writing, however, to seek additional feedback from you and the reviewers which would greatly help us in addressing the peer review comments. In particular we seek further input on the issues of sample size and cycling. Below, we respond to the six main issues that you pointed out in your cover letter with questions and requests for guidance. Given that this was an anonymous review, they may want to respond in writing but we would also welcome a dialogue, perhaps even a conference call, with our project team to allow for in-depth discussion and to reduce the amount of time needed for back and forth correspondence. Also, on several comments below we note that they run counter to the guidance from NPS. These may require additional conversations between you and Penny to give us additional guidance.

**Review Point 1.**

- A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

The Northwest Forest Plan suggests that more than 50 pairs should be monitored or ideally more than 75-100 (Lint, Joseph et al. 1999, Northern Spotted Owl Effectiveness Monitoring Plan). If this were applied to the SFAN spotted owl population, it would require a complete census of our study area and even then, may not be possible because of the available number of pairs and site access.

For occupancy, the sample size (n=20) selected in our protocol was based on a 78% probability of capturing a 10% annual decline over 8 years. For fecundity, the sample size (n=20) selected in our protocol was based on a 74% power of detecting a 10% annual decline in fecundity over

12 years. It appears that the main concern is the level of decline that we can detect in not adequate (we would only be able to detect a catastrophic change). This is a good issue to bring up, but we would like additional guidance on what level of change would be considered acceptable. If, for example, we increased our sample size to n=30, it would increase power to 88% power of detecting a 10% annual decline over 12 years, would reviewers find that to be adequate?

Related to this issue, reviewers also pointed out that the current sample size of 20 would be adequate if data can be rolled up with regional studies. It should be noted that our data currently contribute to a county-wide data set on spotted owls in this region. PRBO Conservation Science, for example, annually monitors spotted owls on up to 25 sites on non-federal lands. These lands include those managed by Marin County and the Marin Municipal Water District. The focus of their monitoring is tracking site occupancy and reproductive success in areas with management concerns. While their monitoring objective is different, their field methods are identical so that occupancy and fecundity can be compared.

Also, in the past, data collected through this monitoring program were incorporated into the 5-year review (Anthony et al. 2006. Status and Trends in Demography of Northern Spotted Owls: 1985-2003. Wildlife Monograph 163). While we are still collecting occupancy and fecundity data, we did drop banding. The field methods for determining occupancy and fecundity are still compatible with those of the Northwest Forest Plan (NWFP) and can be rolled up with future analyses. Barrowclough et al (page 1117; 2005) notes that monitoring the spotted owl in this region continues to be of interest to the NWFP because it is geographically distinct. Data from our monitoring effort will also contribute towards Recovery Action 3 (conduct occupancy inventory in areas outside of the demographic study areas; USFWS 2008. Spotted Owl Recovery Plan). The question for reviewers is then if we highlighted how data are compatible with the data collected by PRBO and the NWFP, would reviewers view the proposed sample size as adequate or would sample size continue to be problematic?

Related to sample design, in the protocol we proposed a 3-year on 3-year off rotation. We have also considered a 1 year on and 2 year off or a 1 year on 1 year off that would provide us with similar power. We selected the 3/3 design anticipating that it would be easier to hire a technician for 3 consecutive years than to hire and train a new person every other year or every 3rd year. Similarly, the design proposed for landbird monitoring would fall in 3 years on 3 years off and we could cycle these two programs. If the 3/3 design, however is insufficient, we would like thoughts from the reviewers if either of the two other designs 1/1 or 1/2 would be sufficient. We note also that even in our "off" years, PRBO will continue to monitor sites and NPS will also monitor some sites to address park management needs. These sites will not be randomly selected and may not include all monitoring described in the protocol. However, the effort will help us determine if unusual events may be occurring during a year (such as the non-nesting year in 2007). Guidance on cycling will be very helpful because if cycling of any kind is unacceptable, then our board and steering committee must make serious decisions that would require us to drop the spotted owl or another monitoring program.

**Review Point 2.**

- Methods are well-described but are unlikely to be effective in establishing no occupancy (R2).

We are using the same standard as in the NWFP to determine site occupancy including day visits to look for signs of use (white wash and pellets), night calling, and in some cases pre-dawn visits or searches of a larger area around previous sites. Occupancy analyses of our 1999-2005 data indicate that surveying a site twice during the day and once at night within a season would give a 98% probability of detection. In addition, we are awaiting the release of the updated USFWS northern spotted owl protocol (expected in 2009) that will help define the probability of detecting spotted owl presence or absence given the presence or absence of a barred owl. If the reviewer has something else in mind can they point us to acceptable standards?

**Review Point 3.**

- There is a pressing need to correlate change in owl populations with causes, but neither sudden oak death nor barred owls will be monitored in sufficient detail to establish cause (R1, R2).

We agree that this is a pressing issue but this is a research topic rather than a component of the monitoring protocol. Golden Gate NRA has received funding in 2007 to conduct a barred owl study to evaluate effects on spotted owls. The study did not get implemented because of the small population of barred owls in our study area (1 pair). Funding has been requested again for the years 2010-11. In regards to incorporating barred owl monitoring into spotted owl monitoring, according to the Northern Spotted Owl Recovery Plan (May 2008), there is no consensus on how to monitor barred owls within areas inhabited by spotted owls.

Similarly, there has been recent research on the prevalence and distribution of Sudden Oak Death (SOD) at Point Reyes NS and Golden Gate NRA. Not all of the results were presented in the protocol and the research is on-going and is a coordinated effort by several agencies and universities. This work is also continuing into 2009. In addition, we note that spotted owls exhibit site tenacity that can result in a time lag (delayed response to habitat change). This may confound the immediate effects of SOD on spotted owl biology. In the near future, we may be able to determine a correlative effect by evaluating our long-term spotted owl occupancy and reproductive data with current and available SOD monitoring data.

Although research is ongoing or planned, the main point is that while long-term monitoring should be able to detect trends, monitoring may not necessarily determine cause and effect. The direction we received from the national program is that once trends are detected, it is reasonable that additional research may be triggered to look for causal links. While we can strengthen the section of the protocol dealing with triggers for more research or management (see Review Point 4 below), the request to expand monitoring to SOD and barred owls or the myriad of other potential threats listed by R1, is outside of the scope of vital signs monitoring. As far as we know, the NWFP has not done this either.

**Review Point 4.**

- There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2).

While we agree that this section can be enhanced, determining specific management actions are difficult if not impossible without knowing causal links. We expect that once a "trigger" is met, additional research will be needed to determine causal links. Only after that can management actions be seriously considered.

Reasonable triggers for more research that we are considering include:

a. a decline in productivity and/or occupancy of > 50% in one year,

b. reproductive failure for 3 out of 6 years, and

c. barred owls are documented at >10 spotted owl sites in any given year.

If the reviewers have other reasonable triggers in mind, we would greatly appreciate their input.

**Review Point 5.**

- Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

As in the Review Point 3, research on prey base and a foraging area are outside of the scope of this monitoring effort. The reason nest site characteristics have been incorporated into the study is because it is very simple to do with virtually no extra cost to the field crew. It also provides us with a good indication of major habitat changes that may be occurring around the nest sites. The reviewers are correct that if owl numbers change for other reasons (such as foraging area characteristics), research will be needed. Foraging research has been conducted in the park by PRBO Conservation Science (see Fehring et al. 2003) and could be conducted again if owl productivity changes. Similarly, if the extent or intensity of SOD increases, additional foraging or habitat research may be warranted.

**Review Point 6.**

- Long-term trend analysis needs more definition.

We can add more information here. Connor and Lebuhn (quantitative ecologists at San Francisco State University working with the spotted owl team) suggest that trend analyses can be conducted by fitting the appropriate ANOVA model or occupancy model to the respective fecundity and occupancy data, and examining tests for linear or quadratic trends and for temporal differences in the fecundity data, and a likelihood ratio test for a year effect on occupancy in the occupancy data. Such analyses could be updated each year after data are obtained for the current year.

**Other Points**

Mousing: R1 notes a concern about reduced mousing in our protocol. Early in the monitoring program, we followed the standard NWFP protocol. However, staff noted that owls were frequenting campgrounds, following hikers and roosting on deck railings of homes. Park managers decided at the time that causing habituation to spotted owl was **not acceptable** in this study area. Staff began to field test a modified approach that would reduce habitation of owls to people. The modified protocol relies on increased survey effort over mousing. This often succeeds because nests are generally platform types and not cavity types. Mousing is still conducted as a last result. When developing the modified approach in 1999, field staff tested the methods and compared results to the standard NWFP methods. Park staff also consulted with NWFP biologists to ensure data consistency while still meeting park expectations for reduced mousing. Given that data were comparable with our monitoring effort, they were included in the 5-year review (Anthony et al. Status and Trends in Demography of Northern Spotted Owls: 1985-2003. Wildlife Monograph 163).

Banding: While the reviewers expressed concern that we were not banding we would like more guidance about the reason for this. As noted above, we believe that our methods are compatible with the NWFP for occupancy and fecundity monitoring. Banding would initially increase the work load but may provide increased efficiency in the field. We would have to determine if banding for the sake of increasing our efficiency is a good justification. Additional insight from the reviewers on why we should band would be helpful.

Protocol: R1 noted that, "Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon." As noted above, our methods are consistent. If the reviewer can provide specifics as to what aspect of our field methods the reviewer is most concerned with, it would be very helpful.

Thank you for your help. We look forward to your and/or the reviewers' response.

Happy Holidays,
Marcus

*****************************************************
Marcus Koenen
Inventory and Monitoring Coordinator
San Francisco Bay Area Network (SFAN)
*****************************************************

# Appendix SOP 7D: April 2009 PWR response to SFAN peer review clarification letter.

In April 2009, Dr. Jim Agee responded to the letter from the SFAN and park staff presented in Appendix SOP 7C. Dr. Agee's letter is included below as Appendix SOP 7D. Responses from the SFAN are included in italics.

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UNIVERSITY OF WASHINGTON

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April 20, 2009

The review of the SFAN network response to the initial peer review of the Northern Spotted Owl protocol has been completed. We sent the 2008 version of the protocol, the 2008 peer review, and the network's response to two reviewers familiar with northern spotted owl issues. We'll call them here reviewer 3 and reviewer 4. Note that reviewer 3 was reviewer 2 in the 2008 review. The 2008 peer review raised five major issues, and these are addressed by each reviewer below. The review is organized as follows:

- Issue raised by 2008 peer review
- Network response
- Reviewer 3 comments
- Reviewer 4 comments
- PRC (Agee) conclusions

At the end of this letter is a summary of findings.

## Review Point 1. A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

**Network response.** The Northwest Forest Plan suggests that more than 50 pairs should be monitored or ideally more than 75-100 (Lint, Joseph et al. 1999, Northern Spotted Owl Effectiveness Monitoring Plan). If this were applied to the SFAN spotted owl population, it would require a complete census of our study area and even then, may not be possible because of the available number of pairs and site access. Related to sample design, in the protocol we proposed a 3-year on 3-year off rotation. ….Guidance on cycling will be very helpful because if cycling of any kind is unacceptable, then our board and steering committee must make serious decisions that would require us to drop the spotted owl or another monitoring program.

**Reviewer 3 response**. Noted above, 50 pairs are recommended by Northern Spotted Owl experts, which likely would require a complete census. It is not clear to me why the Network is asking the peer reviewers to find a solution for achieving something less than what experts have already tested and recommended (from 8 demography locations studied for more than 20 years). If documenting long-term trends of the Northern Spotted Owl is a high priority Vital Sign for this network, then the Network needs to provide effective design and sufficient resources to achieve what experts are recommending. There is a reality check that the Network seems unwilling to address; that is, rare, wide-ranging vertebrates are expensive to monitor effectively, and there are few, if any, short cuts. The question on the table is less about science and reconciling comments by peer reviewers and more about whether or not the Network is capable or willing to provide sufficient resources to monitor this species effectively.

Dr. Agee's October 1, 2008 letter stated the following: "The small sample size is less an issue if the methods are compatible with those of other agencies, so that this protocol can be part of a larger dataset. On its own, it will need a larger sample size." Dr. Agee stated the problem and solution, succinctly. Building on this point: increase the sample size by forming a "regional" partnership (agreement) to monitor trends of the Owl at a broader geographic scale than the parks alone. To achieve this, the Network's monitoring objectives, analyses, and interpretations would need to be revised, to project trends broader than at a multi-Park scale. While the design, analytical methods, and reporting would shift to a larger scale, monitoring implemented on NPS land could continue to inform land managers of the Owl's <u>status</u> locally. A partnership approach has its risks, however. If partners pull out, then implementation of the protocol is in jeopardy.

**Reviewer 4 response**. We agree with the reviewers that the sample size is pretty small. In addition, we question the value of doing just a portion of the demographic monitoring protocol, fecundity monitoring. The demographic meta-analyses has illustrated that the main driver of spotted owl lambda is adult female survival, not fecundity. Although fecundity is interesting, if the main question is spotted owl population trends, and you can't measure survival (which you can't without banding) then I think the network would be better served, and have a more powerful monitoring program if their effort focused solely on occupancy monitoring. Given the level access and spotted owl density, I suspect that they could get to almost all of the 60 sites. Occupancy monitoring would require fewer visits per site, and consequently for the same level of effort, more sites could be sampled, the area of inference would be greater, as would the power to detect trend.

I understand all too well the financial constraints with the I&M program, and do not have serious reservations with an on and off cycle of NSO monitoring, especially if the sample size is increased. However, I am a bit concerned about a 3 on and 3 off cycle. In many other NSO monitoring areas an every other year breeding cycle is prevalent. If the SFAN gets into that cycle, data would may hard to interpret because you could be in a situation where the trends would be either biased high (2 good years and one bad) or low. I suggest it might be better to a 2 year cycle.

**PRC Conclusions**. The reviewers agree that the sample size is too small, and there just are not short cuts to solve this problem. It's the network's call on whether you want to focus on fecundity or occupancy, and whether a 3-on/3-off or 2-on/2-off yearly sampling cycle is best (Reviewer 4 seems to have a good justification for 2-on/2-off).

> *This protocol includes a revised sample design that includes annual sampling and increases the number of sites sampled. Details are presented in Section 2.0. We are proposing to monitor an annual panel of 28 sites for occupancy and fecundity. The remaining 32 sites within the study area are split into four panels of 8 sites each, which will be visited over a four year period. With 8 additional sites monitored each year, we reach a total of 36 sites monitored annually (28 + 8). The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater.*

## Review Point 2. Methods are well-described but are unlikely to be effective in establishing no occupancy (R2).

**Network response**. We are using the same standard as in the NWFP to determine site occupancy including day visits to look for signs of use (white wash and pellets), night calling, and in some cases pre-dawn visits or searches of a larger area around previous sites. Occupancy analyses of our 1999-2005 data indicate that surveying a site twice during the day and once at night within a season would give a 98% probability of detection. In addition, we are awaiting the release of the updated USFWS northern spotted owl protocol (expected in 2009) that will help define the probability of detecting spotted owl presence or absence given the presence or absence of a barred owl. If the reviewer has something else in mind can they point us to acceptable standards?

**Reviewer 3 response**. The approaches provided are okay.

**Reviewer 4 response.** I agree with the SFAN network, their methods are well documented to do well in detecting NSO's, and with a formal occupancy analysis, with a proportion of the sites being revisited, one would be able to assess detection probability and possible changes in detection over time. We suggest that SFAN model occupancy as Gail Olson did using the MacKenzie et al 2003 methods, where changes in detect ability would be accounted for in the estimation of occupancy rate, regardless of the cause (breeding status, weather, barred owls, habituation, etc).

**PRC conclusions**. Network approach is acceptable.

## Review Point 3. Correlate changes in owl populations with causes.

**PRC conclusions**. There was no network response to review point #3. It dealt with measures of barred owl populations or sudden oak death as causal factors for changes in spotted owl populations.  As these are likely research topics, they should not be required as part of a monitoring protocol.  However, if the nest tree part of the protocol is retained, it seems that SOD could be monitored in the vicinity of nest trees quite easily.

> *A SOD severity index has now been included to rapidly assess the state of SOD in around activity centers. Details for SOD data collection are provided in SOP 2: Standard Field Procedures.*

## Review Point 4.  There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2).

**Network response**.  While we agree that this section can be enhanced, determining specific management actions are difficult if not impossible without knowing causal links. We expect that once a "trigger" is met, additional research will be needed to determine causal links.  Only after that can management actions be seriously considered.

Reasonable triggers for more research that we are considering include:

a. a decline in productivity and/or occupancy of > 50% in one year,
b. reproductive failure for 3 out of 6 years, and
c. barred owls are documented at >10 spotted owl sites in any given year.  If the reviewers have other reasonable triggers in mind, we would greatly appreciate their input.

**Reviewer 3 response**.  The triggers provided are okay, as long a brief rationale is provided.  Re: management actions: Recommend providing additional information by reviewing known management actions or proposed management actions (published and unpublished) (e.g., the ongoing USFWS Barred Owl removal study was a management action).  The best sources are the Recovery Plan(s) and USFWS 5-year reviews, as well as, contacting the USFWS directly on this topic, then adapt accordingly as NPS management actions to consider.

**Reviewer 4 response**.  I have always struggled with this issue, especially for a species that is a regional management issue.  SFAN management team needs to decide what they will do under what situations.  One suggestion would be management actions to take if there is an increase in barred owls and decrease in spotted owl occupancy.  Because they are at the beginning phase of the invasion, they most likely can take effective action, or at least try, if the Park (s) decide that is something the can and should do.

**PRC conclusions**.   Reviewer 3 is clear and reviewer 4 somewhat less so, but the management triggers appear reasonable and acceptable.  Make sure they are presented in the protocol revision not as triggers to be "considered" but triggers that will be employed.

> *Two key management triggers have been added that are closely linked with our ability to detect trends.*

- *A 4% annual decline or greater in pair occupancy in 5 consecutive years of monitoring.*
- *A 10% annual decline or greater in fecundity in 5 consecutive years of monitoring.*

*The thresholds for these management triggers are a product of the power analysis conducted by Starcevich and Steinhorst (2010; Appendix A) and the adopted sample design for the monitoring program (see Section 2.0 Sample Design)*

*The previously identified management triggers were left in because they will serve to help identify unexpected , yet catastrophic changes that could occur and would trigger immediate consultation with USFWS.*

## Review Point 5: Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

**Network response.** As in the Review Point 3, research on prey base and a foraging area are outside of the scope of this monitoring effort. The reason nest site characteristics have been incorporated into the study is because it is very simple to do with virtually no extra cost to the field crew. It also provides us with a good indication of major habitat changes that may be occurring around the nest sites. The reviewers are correct that if owl numbers change for other reasons (such as foraging area characteristics), research will be needed.

**Reviewer 3 response.** No response.

**Reviewer 4 response**. I do question the value of continuing to measure nest tree characteristics. If the network is concerned about habitat changes, then that should be measured or assessed either through this or another (vegetation monitoring ?-) protocol. If nest trees are being monitored for management and compliance (e.g., to protect all known nest sites) that that should be just stated. My understanding is that vital signs monitoring is to detect change, and if change is detected, we are to do targeted research to understand what is going on. Monitoring foraging habitat and prey base is way beyond what the program is supposed to do.

**PRC conclusions.** Network response is acceptable.

## Review Point 6. Long-term trend analysis needs more definition

**Network response**. We can add more information here. Connor and Lebuhn (quantitative ecologists at San Francisco State University working with the spotted owl team) suggest that trend analyses can be conducted by fitting the appropriate ANOVA model or occupancy model to the respective fecundity and occupancy data, and examining tests for linear or quadratic trends and for temporal differences in the fecundity data, and a likelihood ratio test for a year effect on occupancy in the occupancy data. Such analyses could be updated each year after data are obtained for the current year.

**Reviewer 3 response**. The protocol authors seem to be struggling with this section, nibbling around the edges without taking it on directly. I will repeat my original comment because I believe the intent at that time was clear:

"Narrative section 4.6 lacks any explanation of what kind of analyses will be done to determine statistically significant long-term trends. This is the most important analysis of the monitoring project."

The protocol is incomplete without addressing this point sufficiently. I recommend that authors contact one or more NPS or I&M quantitative ecologists who have completed this section of a protocol for a vertebrate species and/or contact Tom Philippi, I&M Quantitative Ecologist, to assist and provide more comprehensive perspective on the expectations for this section of the protocol.

**Reviewer 4 response**. Unfortunately, given our recommendations above, the network will need to go back to their statisticians. However, occupancy analysis is becoming fairly common, so I don't think this should be too hard to do (I hope).

**PRC conclusions**. The network needs to more specifically address the issue of long-term trends.

> *Additional information has been added to both the narrative, specifically in Section 4.4 and 4.6, and in detail in SOP 5: Data Analysis and Reporting for conducting the long-term occupancy and fecundity trend analyses. Instructions are also provided for the occupancy and fecundity trend analysis using the VGAM package of the R Project for Statistical Computing in the appendix to SOP 5.*

**Other review comments made by reviewer 4:**

**Mousing**: We don't have any concerns with the consistency of SFANs methods.

**Banding***:* There are advantages to banding, but in the original review it was decided that they were outweighed by cost and impact to the owls. We don't have concerns about the impacts of capture. They might have less overall impact if the monitored owls were banded and could be quickly identified this way, in fact it might save costs overall. This is a decision they should make with input from the field crew. However, if SFAN switches to occupancy monitoring, banding would not be required.

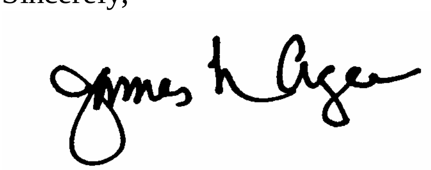
**Protocol:** R1 noted that, "Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon." I agree with SFAN. I'm not sure what is this reviewer's intent, except to perhaps have SFAN do full blown demographic monitoring, which they are not required to do, nor do they have the resources to do. In addition, as they state above, the recovery plan does call for occupancy monitoring outside of the demographic areas, which is what they will be doing.

## Summary of conclusions.

On review points 1 and 6, the reviewers agreed that the sample size was too small and that long-term trend analysis needs to be more specifically defined. On review points 2, 4 and 5, the reviewers agreed that the approach taken by the network for site occupancy and management thresholds is adequate. Reviewer 5 questioned the need for measuring nest tree characteristics, but if it can be afforded I see no reason that it should not be acceptable.

I hope this additional review has provided adequate guidance to the network to complete an acceptable protocol for northern spotted owl. Please remember to address not only the comments in this supplementary review but also those made in the 2008 review before resubmitting the protocol.

Sincerely,



James K. Agee

PWR Protocol Review Coordinator

# Appendix A: Analysis of power to detect trends in occupancy and fecundity in prairie falcon and spotted owl populations

## San Francisco Bay Area Network
## of the
## National Park Service

Authors:
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March 2010

In Partial Fulfillment of
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**ACKNOWLEDGMENTS**

The authors would like to thank Marcus Koenen, David Press, Bill Merkle, and Gavin Emmons of the San Francisco Area Network for providing helpful background for this analysis and Kathryn M. Irvine for her help with occupancy modeling.

## 1. INTRODUCTION

The San Francisco Bay Area Network (SFAN) of the National Park Service (NPS) has identified prairie falcon and spotted owl populations as two of the network's Vital Signs for long-term monitoring. Specifically, trends in occupancy and fecundity will be monitored so that detrimental changes in the population can be identified to inform timely management decisions. The analysis approaches for measures of occupancy and fecundity are first discussed, and then power to detect trends in occupancy and fecundity is computed for all metrics of interest for the two species.

## 2. GENERAL ANALYSIS APPROACH

The models for both occupancy and fecundity incorporate zero inflation. For occupancy analysis, extra zeroes may result from imperfect detection. When measuring fecundity, counts of hatchlings or fledglings might be subject to zeroes from nest failures due to non-nesting pairs, predation, or environmental factors. Analysis methods for zero-inflation apply mixture models that combine one distribution for the extra zeroes and another distribution for the remaining zeroes and non-zero outcomes so that measures of occupancy and fecundity can be accurately estimated (MacKenzie et al. 2006). The number of detections for occupancy analysis and the number of hatchlings or fledglings for fecundity analysis are modeled as zero-inflated binomial random variables.

### *2.1 Occupancy and trend modeling*

Let $y_{ijk}$ be the outcome for site *i*, year *j*, and visit *k*, and let $y_{ijk}$ take a value of 1 if a prairie falcon is detected and 0 otherwise. Let $y_{ijk}$ be the number of detections made at site *i* and year *j* during the $k^{th}$ visit. The zero-inflated binomial distribution is expressed as:

$$P\left(Y = y_{ijk}\right) = \pi_{ij} p_{ij}^{\ y_{ijk}} \left(1 - p_{ij}\right)^{1-y_{ijk}} + \left(1 - \pi_{ij}\right) I\left(y_{ijk} = 0\right),$$

where $\pi_j$ is the occupancy rate in year *j* and $p_{ij}$ is the detection rate for site *i* and year *j*. Assume that there are *S* sites, *T* years, and *K* visits to a site each year. Define the indicator function as $I\left(y_{ij} = 0\right)$ as 1 when $y_{ij} = 0$ and 0 otherwise. This model assumes an equal number of visits to a site within a year, but *K* can vary among sites or among years.

Occupancy ($\pi$) is modeled with logistic regression as a function of related covariates:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)=\gamma_0+\gamma_1 x_{ij},$$

where $x_{ij}$ represents a covariate for the $i^{th}$ site and the $j^{th}$ year. Multiple site-level or year-level covariates may be incorporated. To test for linear trend in the logged odds ratio of occupancy, the year covariate should be included as a predictor in the occupancy model. The probability of zero inflation (p) is simultaneously estimated by logistic regression:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right)=\beta_0+\beta'_1 x_{ijk},$$

where $x_{ijk}$ represents a covariate collected at the $i^{th}$ site and $k^{th}$ visit during the $j^{th}$ year.

The implicit dynamics occupancy model is assumed for this analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

Maximum likelihood is used to estimate the regression coefficients from the models for occupancy and detection rates. Occupancy can be modeled at the site-by-year level so predictors should be collected at the site level, year level, or site-by-year level. Detection probabilities are allowed to vary at each visit for each site and year, so covariates are often environmental covariates that vary from visit to visit (MacKenzie et al. 2006). However, if detection rates are also changing over time, a model that includes a year covariate may be needed for accurate occupancy estimation. Model selection is conducted using the Akaike Information Criterion (AIC). Model output is examined to be certain that valid variance estimates are obtained. When valid estimates of the variance cannot be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance is used.

### *2.2 Fecundity and trend modeling*

Fecundity is monitored with counts of hatchlings or fledglings observed at each nest. These outcomes are also modeled with the zero-inflated binomial model. Let $y_{ij}$ be the number of hatchlings or fledglings detected in occupied site *i* and year *j*. Let *n* be the number of occupied sites and T be the number of years monitored for fecundity. The probability mass function of *Y* is:

$$P\left(Y=y_{ij}\right)=\pi_{ij}\binom{M}{y_{ij}}p_{ij}^{\,y_{ij}}\left(1-p_{ij}\right)^{M-y_{ij}}+\left(1-\pi_{ij}\right)I\left(y_{ij}=0\right),$$

where $\pi_{ij}$ is the probability that an extra 0 is **not** observed at site $i$ in year $j$, $p_{ij}$ is the probability of a hatchling/fledgling at site $i$ in year $j$, $M$ is the maximum number of hatchlings/fledglings seen in any nest, and $I(y_{ij} = 0)$ is 1 when $y_{ij} = 0$ and is 0 otherwise. Maximum likelihood estimation is used to obtain estimates of the regression coefficients in each model, and the invariance property of maximum likelihood estimates is used to obtain estimates of $\pi_{ij}$ and $p_{ij}$. To test for trend in fecundity, the year covariate is included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change in $p_{ij}$ over time.

### *2.3 Power approach*

Power is often calculated assuming large-sample properties for hypothesis tests of significance. However, the assumptions necessary for assuming asymptotic normality are extensive and often difficult to verify (Sumathi and Aruna Rao, 2009). Ridout et al. (2001) observed that the normal approximation to the score test underestimates the true test size for testing the significance of the dispersion parameter when comparing the zero-inflated negative binomial and zero-inflated Poisson distributions. Jung et al. (2005) corrected this problem with a parametric bootstrapping approach to significance testing, which provided uniformly higher power. For both prairie falcon and spotted owl monitoring, trend is tested with the likelihood ratio test, which demonstrates power equal to or higher than that provided by the Wald test (Lyles et al. 2006).

Model selection for occupancy and fecundity is conducted using the pilot data for prairie falcons and spotted owls. In each case, the model with the lowest AIC score with a valid variance-covariance matrix is used in the power analysis. In all four cases, power is computed via a parametric bootstrap. For each bootstrap sample, the likelihood ratio test of trend is conducted by applying the selected model with and without the term for trend. Power is calculated as the proportion of times that the null hypothesis is rejected for the one-sided alternative hypothesis of decreasing trend, i.e.

$$H_o : \beta = 0 \text{ vs. } H_a : \beta < 0 .$$

Power must be approximated assuming that tests of trend are conducted at a specific Type I error rate. The Type I error rate, designated as α, is the probability of rejecting a true null hypothesis. For two-sided tests of trend, a Type I error would mean that the population was found to be changing when it was not. A Type II error occurs by failing to reject a false null hypothesis and thus concluding no change has occurred. For long-term monitoring, the cost of a Type I error may be far less than the cost of a Type II error. Mistakenly rejecting a true null hypothesis (Type I error) may trigger a management conservation action that is not actually needed. However, failing to detect a significant trend may have deleterious effects that cannot be reversed by the time the trend is actually detected. A conservative approach is to use a larger α value for higher power and reduced probability of a Type II error (Buhl-Mortensen 1996; Gibbs, et al. 1998; Mapstone 1995). For this power analysis, an α value of 0.20 is used. Power does not fall below the α value assumed for the trend test.

### *2.4 Revisit designs*

Revisit designs specify the schedule of sites visitations by year for the duration of the monitoring period. Revisit design allow balance over space and time of available survey effort. The notation of MacDonald (2003) is used to describe the revisit designs.

The notation employs a string of numbers, dashes, and commas to identify the revisit design among panels. The numbers in odd-numbered positions will designate the number of consecutive visits to a panel before it rotates out of the revisit schedule. Digits in the even-numbered positions indicate the number of sampling occasions that the panel will not be revisited. Therefore, a revisit schedule of [1-0] indicates that the panel will be revisited each year and never rotated out of the schedule. This revisit schedule is equivalent to taking a random sample of sites and visiting them every year. The [1-n] revisit design represents a sampling design in which independent random samples are taken every year. A [2-2] revisit design consists of one panel visited for two consecutive years and then rested for two consecutive years before beginning the cycle again. Differing revisit schedules among panels are indicated by separating the digits in parentheses by commas within the brackets. For example, a revisit schedule of [(1-0), (1-3)] indicates that the revisit design includes an annual panel that is revisited every year and four panels that are visited for one year then not visited for the following three years before being rotated back into the design.

A random site effect may be incorporated in the occupancy or detection model to account for variation among sites. However, implementing the appropriate correlation structure in a mixed model approach may be problematic with maximum likelihood estimation (MacKenzie et al. 2006). Incorporating numerous fixed site effects may exhaust available degrees of freedom making variance estimates unreliable and trend testing inaccurate. Without fixed or random site effects, the data are treated as if collected from a [1-n] revisit design. This revisit design has the lowest power for trend detection (Urquhart and Kincaid, 1999), so power results are conservative. Since site effects are difficult to incorporate, MacKenzie et al. (2006) suggest using a [1-0] design so that unexplained variation among sites is minimized for more accurate tests of trend. Incorporating relevant site-level covariates into the occupancy model will also help explain differences in occupancy from site-to-site.

## 3. PRAIRIE FALCON POWER ANALYSES

SFAN, in cooperation with Pinnacles National Monument (PINN), has monitored the occupancy rate and fecundity measures of the prairie falcon population in PINN since 1984. SFAN personnel are interested in monitoring trends in occupancy and fecundity measures. This section will address the power to detect changes in prairie falcon occupancy and fecundity measurements over time.

### *3.1 Survey design*

The target population includes 36 territories historically used by prairie falcon in PINN. Of the 36 territories in the target population, 18 of these territories fall into the "core" area. The core area consists of territories that are more accessible to climbers and hikers. These areas have been surveyed more consistently and frequently over the last 22 years to assess hiking/climbing pressure during the breeding season. Eighteen non-core areas were identified and added to the sample over time. Due to the added monitoring importance of the core areas, the core and non-core areas will be treated as separate strata with core territories censused annually. Depending on survey resources and the results of the power analysis, the non-core territories will be either censused or allocated to a set of panels that are visited on an alternating cycle.

Sites are visited at least 3 times each year with visits lasting 1 to 4 hours. At least 3 visits to a site are needed to determine that a site is unoccupied, and visits are spaced 21 to 28 days apart. In sites where prairie falcon detections are made, territorial occupancy is assessed by examining the behavior of each detected prairie falcon. Territorial behavior is verified by observing courtship or reproductive behavior or by evidence of offspring.

Pilot data collected since 1984 are available with a more consistent effort made since 2002. Detections from Ball Pinnacle and Central High Peaks were excluded because these territories are near other historic territories and are not considered independent territories. Some survey records for territories in which no detections were made were omitted from the database prior to the 2008 survey, potentially causing invalid inference on occupancy and detection rates from the incomplete data set. For this reason, only the 2008 and 2009 data are used for the power analysis. This database problem does not affect the fecundity data set because the subset of pair-occupied sites is the target population for fecundity monitoring. Fecundity monitoring data were collected from 2002 to 2009. While fecundity data are available since 1984, the data collected since 2002 represent the current methodology and are thought to be more consistent.

SFAN is interested in approximating the power to detect trends in occupancy and fecundity measures. For a Type I error rate of 0.2, the power to detect a 50% decline in each indicator of interest over a 10-year period in a one-sided alternative hypothesis is examined for several sample sizes and revisit designs.

### *3.2 Occupancy analysis*

The definition of occupancy requires a verification of territorial behavior. A prairie falcon detection does not necessarily imply that occupancy has been established. Designation of site occupancy requires multiple site visits within a year and evidence of territorial behavior. To estimate occupancy according to the SFAN definition of occupancy, only detections verifying territorial behavior should be used. Detection probabilities from this analysis would reflect the detection of an individual or pair displaying territorial behavior. However, the current data set reflects all detections regardless of behavior. Therefore, occupancy may be overestimated in this analysis. Data analysis may be improved by recording an indicator that the detection provides proof of territorial occupancy. This field could be recorded as a 0/1 binary field rather than a descriptive field for easier data analysis.

The pilot data are examined to determine if the estimated detection rates for prairie falcon are substantially less than one, indicating that occupancy estimates should be calculated assuming imperfect detection. In the next section, the occupancy analysis approach and concurrent estimation of trend over time are discussed. All occupancy estimates relate to pair occupancy since no single prairie falcons were observed in 2008 or 2009.

#### *3.2.1 Evaluation of detection probabilities*

Maximum likelihood estimation was used to obtain estimates of regression coefficients for models of occupancy and detection rates. Occupancy models were based on a site-level covariate (an indicator for core area) and the survey year. Detection models were based on covariates collected within each site and year such as month, high temperature, low temperature, average wind speed, cloud cover, and level of precipitation. The occupancy model selected from the modeling exercise contained covariates for the year and core area inclusion. The three detection models with the lowest AIC are given in Table 3.1. The lowest detection probabilities from the first model were obtained for the relatively-few PRFA surveys conducted when precipitation was present. Because the AIC for the month-only detection model is only slightly larger, this more parsimonious model is used for model stability.

Table 3.1: Best detection models from 2008-2009 pilot data

| Detection model variables | AIC | Range of estimated detection rates | 2008 estimated occupancy rate (SE) | 2009 estimated occupancy rate (SE) |
|---|---|---|---|---|
| Hi_TempF, CCPct, Precip_Code | 518.31 | 0.3011 – 0.6965 | 0.9271 (0.1020) | 1.0000 (0.0031) |
| Month, Precip_Code | 519.84 | 0.3281 – 0.6511 | 0.8788 (0.0957) | 1.0000 (0.0016) |
| Month | 520.27 | 0.3305 – 0.6513 | 0.8787 (0.0956) | 1.0000 (0.0010) |

Plotting the estimated detection probabilities against the month predictor (Figure 3.1), one may observe that detection probabilities for PRFA are highest later in the season. A *t*-test of the two-sided hypothesis that the mean detection rate is equal to 1 is highly significant (p-value < 0.0001). There is no evidence that PRFA detection probabilities are so high as to warrant conducting a trend analysis that assumes perfect detectability. Therefore, the zero-inflated Bernoulli distribution is assumed.

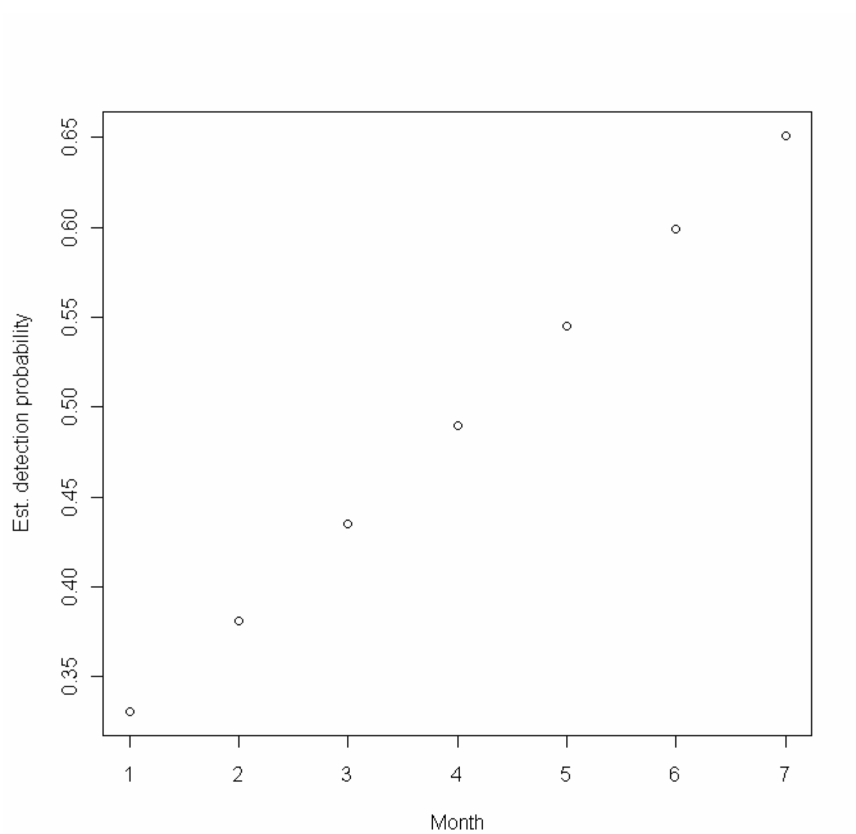


*Figure 3.1: Estimated detection probabilities by month*

### *3.2.2 Power analysis*

The power analysis is conducted using the parametric bootstrapping approach. The models for occupancy and detection obtained from the pilot data are used. The month covariate is randomly selected from the pilot data so that months in which prairie falcon surveys are more common will occur more frequently in the bootstrap samples.

Power is examined for a range of sample sizes that are visited using several revisit designs. Figures 3.2 through 3.5 provide illustrations of several possible revisit designs for a range of annual sample sizes. For each revisit design, the set of core territories is visited annually and all territories are visited at least once over the course of the revisit cycle. Notice that, for the [(1-0), (1-4)] revisit design, 10 years are required to obtain complete replication at all territories. For the [(1-0), (1-1)] design, all sites are visited at least twice in four survey years. When the [1-0] revisit design is used, all sites are visited annually and a complete replicate is obtained after the second survey year.

An issue that arose in the occupancy modeling exercise is the difficulty in obtaining stable maximum likelihood estimates from occupancy and detection models that incorporate an effect for the territory. Fixed effects for each site require considerable degrees of freedom that can result in erroneous variance estimation. Incorporating a random effect into the detection model for a heterogeneous detection probability model generated occupancy estimates very close to 1 in every case. Furthermore, occupancy and detection models with any complexity generally produced Hessian matrices that were not positive-definite, so standard errors for trend estimation could be wrong. Since neither a fixed nor a random effect for territory can be incorporated into the models, the sample is treated as if were collected in a [1-n] design. The revisit designs cannot be distinguished from another because the benefits of sampling the same sites annually cannot be integrated into the model. However, the [1-n] revisit design has lowest power for trend detection, so the power results provided here are conservative.

MacKenzie et al. (2006) suggest that the heterogeneous detection probability model, while difficult to implement in a maximum likelihood setting, may be conducted with a Bayesian approach. When incorporating a fixed or random site effect is not possible, including site-level covariates that are related to occupancy will help explain site-to-site differences in occupancy estimates. Unexplained site-to-site variation is included in the residual error term which increases the standard error of the estimate of the trend coefficient and decreases power to detect trend.

| | | Year | |
|---|---|---|---|
| **Panel** | **Core/ non-core** | **1** | **2** |
| 1 | Core | 18 | 18 |
| 2 | Non-core | 3 | 3 |
| ANNUAL TOTAL | | 21 | 21 |

*Figure 3.2: [1-0] revisit design for annual census of core sites and sample of 3 non-core sites*

| | | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Panel** | **Core/ non-core** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| 1 | Core | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 2 | Non-core | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3 | Non-core | 3 | | | | | 3 | | | | |
| 4 | Non-core | | 3 | | | | | 3 | | | |
| 5 | Non-core | | | 3 | | | | | 3 | | |
| 6 | Non-core | | | | 3 | | | | | 3 | |
| 7 | Non-core | | | | | 3 | | | | | 3 |
| ANNUAL TOTAL | | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |

*Figure 3.3: [(1-0),(1-4)] revisit design*

| | | Year | | | |
|---|---|---|---|---|---|
| **Panel** | **Core/ non-core** | **1** | **2** | **3** | **4** |
| 1 | Core | 18 | 18 | 18 | 18 |
| 2 | Non-core | 6 | 6 | 6 | 6 |
| 3 | Non-core | 6 | | 6 | |
| 4 | Non-core | | 6 | | 6 |
| ANNUAL TOTAL | | 30 | 30 | 30 | 30 |

*Figure 3.4: [(1-0),(1-1)] revisit design*

| | | Year | |
|---|---|---|---|
| **Panel** | **Core/ non-core** | **1** | **2** |
| 1 | Core | 18 | 18 |
| 2 | Non-core | 18 | 18 |
| ANNUAL TOTAL | | 36 | 36 |

*Figure 3.5: [1-0] revisit design for annual census of all sites*

The power to detect a 50% decline in occupancy after 10 consecutive survey years is provided in Table 3.2 for the revisit designs described in Figures 3.2 through 3.5. The [1-0] revisit design is known to have the highest power to detect trend (Urquhart and Kincaid, 1999). As discussed previously, the default revisit design is assumed to be a [1-n] design since the effect of territory cannot be explicitly modeled. Therefore, the difference among the power calculations presented in Table 3.2 is a function of annual sample size rather than an artifact of the revisit design.

Table 3.2: Power to detect occupancy trends for different sample sizes and revisit designs

| Annual sample size of territories | Number of core sites surveyed annually | Number of non-core sites surveyed annually | Revisit design | Power to detect a 50% decrease after 10 consecutive survey years |
|---|---|---|---|---|
| 18 | 18 | 0 | [1-0] | 0.953 |
| 21 | 18 | 3 | [1-0] | 0.973 |
| 24 | 18 | 6 | [(1-0),(1-4)] | 1.000 |
| 30 | 18 | 12 | [(1-0),(1-1)] | 1.000 |
| 36 | 18 | 18 | [1-0] | 1.000 |

Because the core sites must be censused each year to monitor high-use areas, the power to detect trends in non-core sites is examined separately (Table 3.3). The samples will be stratified by core and non-core areas, so trends may be estimated separately for each subpopulation. Comparisons of Tables 3.2 and 3.3 indicate that the high power to detect trends across the set of territories is largely due to the census of core sites. The pilot data did not indicate a significant difference in occupancy between core and non-core sites (p=0.1413). However, if future prairie falcon trends occur at different rates between core and non-core areas or if inference to the subpopulation of non-core sites is of interest, then results for trends in prairie falcon occupancy at PINN may be misleading unless at least between 9 and 12 non-core territories are surveyed each year. If historic data are corrected so that non-detections are included in the data set, the pilot data may be helpful in determining if sample sizes for non-core areas should be considered independently from the annual census of core sites.

Table 3.3: Power to detect occupancy trends for non-core sites only

| Number of non-core sites surveyed annually | Revisit design | Power to detect a 50% decrease after 10 consecutive survey years |
|---|---|---|
| 3 | [1-0] | 0.559 |
| 6 | [1-0] | 0.754 |
| 9 | [1-0] | 0.773 |
| 12 | [1-0] | 0.852 |

### 3.3 Fecundity power analysis

Fecundity will be monitored by examining trends in the binomial probability of hatchlings and fledglings. Histograms of prairie falcon hatchlings and fledglings per nest from data pooled over the years 2002 to 2009 indicate a large number of zeroes in each outcome (Figures 3.6 and 3.7, respectively). The additional zeroes may be a result of mechanisms such as imperfect detection rates, predation, or environmental factors and are accounted for using a zero-inflated binomial model. The maximum number of eggs observed in the pilot data is 5, so this is assumed to be the maximum number of hatchlings or fledglings per nest in PINN.

Assuming that the numbers of hatchlings and fledglings follow zero-inflated binomial distributions and assuming that a random sample of occupied sites are visited each year, the power to detect a 50% decline in fecundity after 10 consecutive survey years is provided for hatchlings (Table 3.4) and fledgling (Table 3.5). The results of the power analysis indicate that annual surveys of at least 10 pair-occupied sites provides power of at least 0.8 to detect a 50% decline over 10 years in hatchling or fledgling rates.

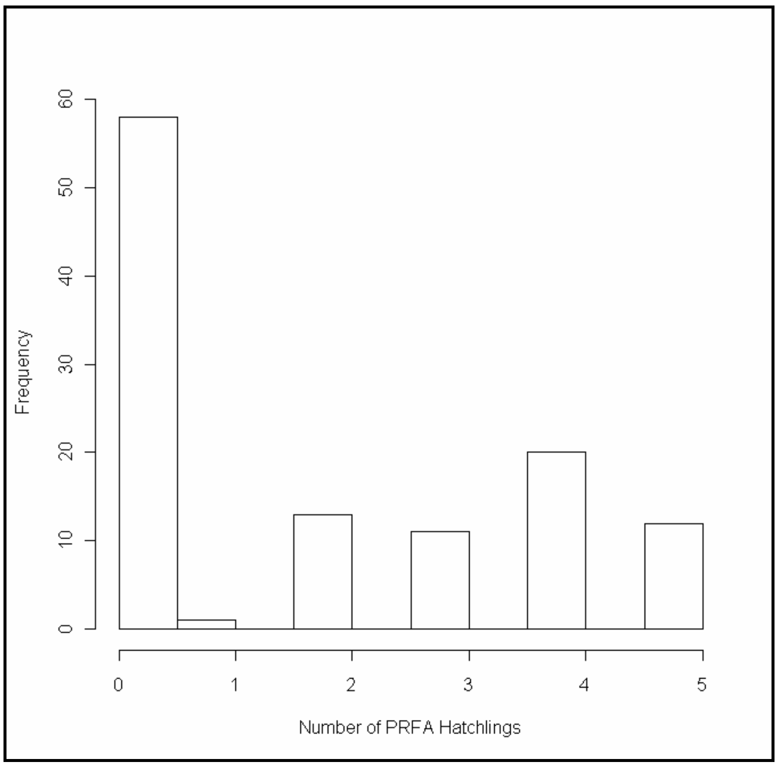


*Figure 3.6: Histogram of hatchlings across years, 2002 - 2009*

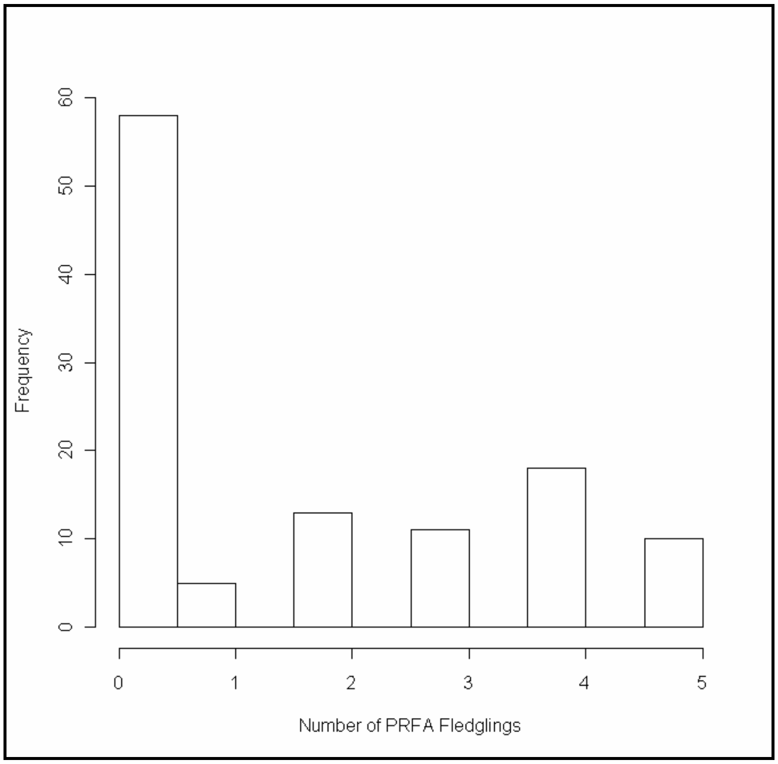

*Figure 3.7: Histogram of fledglings across years, 2002 - 2009*

Table 3.4: Power to detect a 50% decline in the probability of hatchlings

| **Annual sample size of occupied nests** | **Power to detect a 50% decrease after 10 years (based on 2002-2009 pilot data)** |
|---|---|
| 5 | 0.609 |
| 10 | 0.910 |
| 15 | 1.000 |
| 20 | 1.000 |
| 25 | 1.000 |

Table 3.5: Power to detect a 50% decline in the probability of known fledglings

| **Annual sample size of occupied nests** | **Power to detect a 50% decrease after 10 years (based on 2002-2009 pilot data)** |
|---|---|
| 5 | 0.645 |
| 10 | 0.922 |
| 15 | 0.977 |
| 20 | 1.000 |
| 25 | 1.000 |

Core sites are visited annually so that hiking and climbing pressure can be assessed throughout the breeding season. Given that the set of core sites is censused annually, power is examined for samples that contain all core sites and a range of non-core sites each year. For counts of both hatchlings (Table 3.6) and fledglings (Table 3.7), the power to detect trend in the binomial probability for each outcome is one. This level of power is attained even when no non-core sites are surveyed. However, if inference to non-core sites is of interest, then this subpopulation should be sampled with sufficient effort. Power to detect a 50% decline over 10 consecutive years exceeds 0.8 for as few as three sites each year for hatchlings (Table 3.8) and fledglings (Table 3.9).

Table 3.6: Power to detect trend in the binomial probability for **hatchlings** for a census of core sites and a sample of non-core sites

| Annual sample size of territories | Number of core sites surveyed annually | Number of non-core sites surveyed annually | Power to detect a 50% decrease after 10 consecutive survey years |
|---|---|---|---|
| 18 | 18 | 0 | 1.000 |
| 21 | 18 | 3 | 1.000 |
| 24 | 18 | 6 | 1.000 |
| 30 | 18 | 12 | 1.000 |
| 36 | 18 | 18 | 1.000 |

Table 3.7: Power to detect trend in the binomial probability for **fledglings** for a census of core sites and a sample of non-core sites

| Annual sample size of territories | Number of core sites surveyed annually | Number of non-core sites surveyed annually | Power to detect a 50% decrease after 10 consecutive survey years |
|---|---|---|---|
| 18 | 18 | 0 | 1.000 |
| 21 | 18 | 3 | 1.000 |
| 24 | 18 | 6 | 1.000 |
| 30 | 18 | 12 | 1.000 |
| 36 | 18 | 18 | 1.000 |

Table 3.8: Power to detect trend in the binomial probability for **hatchlings** for non-core sites only

| **Number of non-core sites surveyed annually** | **Revisit design** | **Power to detect a 50% decrease after 10 consecutive survey years** |
|---|---|---|
| 3 | [1-0] | 0.875 |
| 6 | [1-0] | 0.957 |
| 9 | [1-0] | 1.000 |
| 12 | [1-0] | 1.000 |

Table 3.9: Power to detect trend in the binomial probability for **fledglings** for non-core sites only

| **Number of non-core sites surveyed annually** | **Revisit design** | **Power to detect a 50% decrease after 10 consecutive survey years** |
|---|---|---|
| 3 | [1-0] | 0.816 |
| 6 | [1-0] | 0.969 |
| 9 | [1-0] | 0.988 |
| 12 | [1-0] | 0.996 |

### *3.4 Conclusions*

Annual surveys of 27 to 30 territories consisting of a census of the 18 core sites and 9 to 12 of the non-core sites for occupancy surveys and at least 10 occupied territories for fecundity surveys should provide power greater than 0.80 for trend detection. Stratified random sampling within the non-core subpopulation will allow inference to that subpopulation of territories. MacKenzie et al. (2006) recommend the [1-0] revisit design so that the additional variation from alternating territories in and out of the survey will not affect variance estimates and therefore the power to detect trends. However, management goals may necessitate the use of serially-alternating revisit designs so that all territories may be visited intermittently.

Gavin Emmons stated that some territorial pairs arrive in the spring rather than in the late winter, so territories designated as "occupied" for that year may actually be unoccupied early in the survey season. This would cause underestimation of detection rates. The pilot data indicate that detection probabilities are lowest in January and gradually increase over the course of the survey season (Figure 3.1). Most of these late-winter visits occur in core territories which are visited throughout the hiking and climbing season. The occupancy model used in this application applies the assumption that occupancy is consistent throughout the monitoring period. Defining the monitoring window so that this assumption is true will allow accurate and precise estimation of occupancy and detection rates. Determining the occupancy sampling time frame *a priori* will not bias the results but will provide more accurate estimation of detection and occupancy rates from a more balanced data set.

## 4. SPOTTED OWL POWER ANALYSES

The monitoring goals of the spotted owl protocol are to detect substantial long-term trends in spotted owl occupancy and fecundity rates at activity sites within NPS boundaries in Marin County, California. The methods described in Section 2 are used to calculate the power to detect trend in spotted owl metrics. Some background on the sampling design is followed by discussions of the power to detect trend in spotted owl occupancy and fecundity rates. For a Type I error rate of 0.2, the power to detect declines of 4%, 10%, 12%, and 15% in each indicator of interest over 5- and 10-year periods in a one-sided alternative hypothesis is examined for several sample sizes of sites and revisit designs. Results from an initial analysis provide the basis for further power analysis to inform survey design choices.

### *4.1 Sampling design*

The spotted owl study area consists of all federal lands within Marin County and includes Golden Gate National Recreation Area, Muir Woods National Monument, Point Reyes National Seashore, and Samuel P. Taylor State Park, as well as a 400m buffer around these parks. The sampling frame consists of all sites within the study area where a spotted owl has been observed in any survey conducted between 1997 and 2006. A total of 66 sites were initially identified from this list. Eight sites were removed due to inaccessibility (on private land or unsafe to access) or close proximity to another site. Two sites were added to the frame that fell just outside of the GIS buffer. The final 60 sites serve as the sampling frame for occupancy monitoring. Occupancy surveys are conducted between March 1 and August 31.

Between March 1 and May 31, nesting status is assessed. From May 1 to August 31, nests are monitored and fecundity measurements are collected. Fecundity surveys are only conducted at sites containing territorial females, including resident single females and both nesting and non-nesting pairs. Sites that do not meet these criteria of a territorial female are omitted from fecundity estimation based on a "non-target" assessment. Inclusion probabilities may be adjusted to account for changes in the sampling frame so that unbiased estimation is achieved. The number of locations monitored for fecundity is given for the pilot data collected from 1999 to 2008 (Table 4.1). For fecundity monitoring, the subset of 48 sites containing a nesting pair during at least one year is used as the sampling frame.

Since fecundity measurements are conditional on territorial female at a monitored territory, the target population can change from year to year. Furthermore, locations that had not previously hosted a territorial female could later be colonized, thus meeting the definition of the target population for fecundity monitoring. Unfortunately, some nests cannot be evaluated for occupancy by territorial females until later in the survey season, so selecting a sample from the set of sites meeting the criteria for fecundity sampling is not possible. Therefore, a random sample from the sampling frame of 48 sites will be used for monitoring. The fecundity sample should be larger than necessary given that roughly 70% of the sites are eligible for fecundity surveys (David Press, personal communication).

Table 4.1: Number of locations sampled for SPOW fecundity monitoring by year

| Year | Number of locations | Number of fecundity locations |
|---|---|---|
| 1999 | 34 | 19 |
| 2000 | 34 | 25 |
| 2001 | 34 | 25 |
| 2002 | 41 | 27 |
| 2003 | 34 | 28 |
| 2004 | 24 | 24 |
| 2005 | 21 | 21 |
| 2006 | NA | NA |
| 2007 | 25 | 12 |
| 2008 | 25 | 12 |
| 2009 | 30 | 26 |

One of six possible occupancy status categories is assigned for each location each year (Table 4.2). These occupancy categories are mutually exclusive, with all locations falling into only one category each year. Ultimately, the most appropriate occupancy model would estimate occupancy trends for all status categories simultaneously so that the sum of occupancy estimates across categories is always one. However, the available literature has not incorporated techniques for estimating occupancy for more than two categories with methods for trend estimation. Given the instability of occupancy and detection models in the univariate case (discussed in the next section), the multivariate case was not explored.

Table 4.2: Occupancy categories

| Occupancy code | Description |
|---|---|
| PR | Resident pair detected |
| PU | Pair detected but pair occupancy not confirmed |
| RS | Resident single |
| SU | Resident single detected but occupancy not confirmed |
| UK | Occupancy status unknown |
| UO | Unoccupied |

To estimate occupancy according to the SFAN definition of occupancy, only detections verifying territorial behavior are used. The proportion of detections falling within each status category is provided in Table 4.3. The majority of detections occurred within locations with a resident pair. Resident single occupancy is rare in comparison. Status categories for which territoriality is unknown (PU, SU, and UK) also occur less frequently. Without adjusting for imperfect detection, observed detection rates imply high occupancy rates for resident pairs. However, some of the categories are quite rare and estimates of the binomial probabilities may be unstable because they are close to 0 (Olkin, et al., 1981).

Table 4.3: Observed status category frequency among all detections by year

| Year | PR | PU | RS | SU | UK | UO |
|---|---|---|---|---|---|---|
| 1999 | 0.82 | 0.03 | 0.03 | 0.03 | 0.02 | 0.06 |
| 2000 | 0.81 | 0.00 | 0.05 | 0.04 | 0.01 | 0.09 |
| 2001 | 0.85 | 0.00 | 0.02 | 0.00 | 0.01 | 0.13 |
| 2002 | 0.89 | 0.00 | 0.04 | 0.02 | 0.00 | 0.05 |
| 2003 | 0.96 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02 |
| 2004 | 0.92 | 0.00 | 0.05 | 0.00 | 0.02 | 0.01 |
| 2005 | 0.88 | 0.00 | 0.04 | 0.00 | 0.04 | 0.03 |
| 2006 | 0.67 | 0.00 | 0.16 | 0.11 | 0.05 | 0.02 |
| 2007 | 0.79 | 0.07 | 0.06 | 0.04 | 0.00 | 0.04 |
| 2008 | 0.79 | 0.02 | 0.04 | 0.07 | 0.01 | 0.08 |

### *4.2 Occupancy analysis*

The pilot data for occupancy modeling are taken from the set of sites chosen for monitoring. Sites outside the SFAN monitoring area were excluded because they do not represent the target population for which trends will be estimated. Covariate information available for occupancy and detection modeling is described in Table 4.4. These variables represent all modeling variables included by SFAN personnel in the pilot data set.

Table 4.4: Covariate information available for occupancy and detection modeling

| Covariate code | Description |
|---|---|
| Year | Year of the survey |
| Month | Month of the survey |
| Barred | Indicator of barred owl detection at a site for a given year |
| Daytime | Indicator that survey occurred during the day |
| Call | Indicator that a call method was used |
| ObsNum | Number of observers present during the survey |

The process of model selection was problematic for the spotted owl pilot data. Because occupancy analysis is based on a nonlinear model, obtaining a positive-definite Hessian matrix was not possible for some models. The Hessian matrix affects the estimates of variance for occupancy and detection regression parameter estimates which affects trend testing. Model selection was conducted using AIC as the model selection criterion (Bayes Information Criterion was also examined but selected similar models). However, models chosen with AIC often did not provide positive-definite Hessian matrices. The model with the lowest AIC and a positive-definite Hessian matrix was used in the power analysis for trend testing. The final occupancy and detection models selected with this approach are provided for each status category in Table 4.5. The final models were often a reduced version of the model with the lowest AIC indicating that simpler models are more stable for occupancy estimation.

The occupancy estimates by category are provided in Table 4.6. For each status category, occupancy estimates are provided either for the model including the indicator of barred owl presence (estimates of occupancy with and without barred owl presence are provided in the second and third columns) or the model without a factor for barred owl presence (occupancy estimates given in the fourth column). Columns for the unused model contain a "-" to indicate that this model was not used. Due to the complexities of estimating trend with a multi-category occupancy classification, a univariate approach was used and occupancy estimates do not sum to 1. Notice that the presence of barred owls in a site and year decreases pair occupancy but increases the single-unknown and unoccupied status categories. This result suggests that the effect of barred owl presence is to reduce pair occupancy and inhibit territorial behavior as evidenced by the positive effects observed in the SU and UK status categories.

Table 4.5: Final occupancy and detection models for each spotted owl occupancy category

| **Status category** | **Occupancy model** $\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)$ | **Detection model** $\log\left(\frac{p_{ij}}{1-p_{ij}}\right)$ |
|---|---|---|
| PR | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij} + \beta_3 \text{ObsNum}_{ij}$ |
| PU | $\gamma_0$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| RS | $\gamma_0$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| SU | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$ |
| UK | $\gamma_0$ | $\beta_0 + \beta_1 \text{Month}_{ij} + \beta_2 \text{Call}_{ij}$ |
| UO | $\gamma_0 + \gamma_1 \text{Barred}_{ij}$ | $\beta_0 + \beta_1 \text{Call}_{ij}$ |

Table 4.6: Occupancy estimates (and standard errors) from the final model for each spotted owl occupancy category

| Status category | Est. occupancy rate for sites with barred owls (SE) | Est. occupancy rate for sites without barred owls (SE) | Est. occupancy rate (SE) |
|---|---|---|---|
| PR | 0.9197 (0.0505) | ~ 1.000 (0.00001) | - |
| PU | - | - | 0.0301 (0.0146) |
| RS | - | - | 0.1614 (0.0428) |
| SU | 0.2562 (0.0960) | 0.1127 (0.0384) | - |
| UK | - | - | 0.0208 (0.0058) |
| UO | 0.1172 (0.0371) | 0.0601 (0.0124) | - |

Fixed and random effects for location were examined in the modeling effort for occupancy and detection rates. Adding a fixed effect for location prohibitively reduced the number of degrees of freedom available for error estimation. Modeling the location effect as a random effect in the detection model produces the heterogeneous detection probability model which is often difficult to implement in a maximum likelihood approach (MacKenzie et al. 2006). In practice, this approach resulted in site-by-year level occupancy estimates very near 1 and with nearly zero variation and corresponding detection probabilities very near zero. Incorporating the random effect into the occupancy model produced similar problems. A Bayesian approach may be more appropriate for a random effects modeling approach (MacKenzie et al. 2006).

The benefit of incorporating a fixed or random effect for location is that repeat visits to the same locations over time can reduce variance and provide more accurate trend estimation. Without a location effect, the data are treated like random samples taken independently each year (a [1-n] revisit design). MacKenzie et al. (2006) argue that the [1-0] revisit design is best for trend estimation because the models cannot distinguish between variation among different locations and that observed over time. However, the implicit occupancy model used in this analysis does not require that the same sites are visited annually because the local extinction and colonization parameters are not explicitly estimated. MacKenzie et al. (2006) recommend that the [1-0] revisit design be used unless destructive sampling occurs. However, the needs of the monitoring program may dictate that all sites be visited periodically, making a revisit design that accommodates those requirements more desirable.

The revisit designs initially under consideration were the [1-0], [2-2], [$(1\text{-}0)^5$,(2-2)], and [$(1\text{-}0)^{10}$,(2-2)] designs (Figures 4.1 – 4.4, respectively, are provided for a set annual sample of 40 sites). The difference in the latter two designs is that an annual panel of 5 sites is used in the [$(1\text{-}0)^5$,(2-2)] design while an annual panel of 10 sites is used in the [$(1\text{-}0)^{10}$,(2-2)] design. As discussed, the trend analysis treats the data as if a [1-n] design has been used. The [1-n] revisit design has the lowest power for trend detection and therefore provides conservative power results. The replication within a location cannot be used to induce a correlation within a location over time to reduce the variance of the trend estimate. The results of the power analysis for the six spotted owl occupancy status categories, monitoring periods of 5 and 10 years, and all revisit designs are provided in Appendix A. Power is given for a one-sided hypothesis test of no change versus a decreasing trend over time. The results of the initial power analysis demonstrate that the revisit designs are indistinguishable when neither the occupancy nor the detection model includes an effect for location.

The detection model exhibited considerable influence on the final estimates of occupancy. Estimated occupancy could vary widely depending on what covariates were included in the detection model. The problems described above indicate that detection models might perform best when they are simple and covariates uncorrelated with predictors used in both the occupancy and detection models are used.

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Panel** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| ANNUAL TOTAL | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |

*Figure 4.1: [1-0] revisit design for an annual sample of 40 sites*

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Panel** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | 40 | 40 | | | 40 | 40 | | |
| ANNUAL TOTAL | 40 | 40 | 0 | 0 | 40 | 40 | 0 | 0 |

*Figure 4.2: [(2-2)] revisit design for an annual sample of 40 sites*

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Panel** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2 | 35 | 35 | | | 35 | 35 | | |
| ANNUAL TOTAL | 40 | 40 | 5 | 5 | 40 | 40 | 5 | 5 |

*Figure 4.3: $[(1\text{-}0)^{5}, (2\text{-}2)]$ revisit design for an annual sample of 40 sites*

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Panel** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2 | 30 | 30 | | | 30 | 30 | | |
| ANNUAL TOTAL | 40 | 40 | 10 | 10 | 40 | 40 | 10 | 10 |

*Figure 4.4: $[(1\text{-}0)^{10}, (2\text{-}2)]$ revisit design for an annual sample of 40 sites*

Power to detect trends in pair occupancy over time (Figures A.1 and A.2) is nearly 1 for trends over either 5 or 10 years. For pairs whose occupancy status is unknown (Figures A.3 and A.4), power is considerably lower, only reaching 0.8 for annual declines of over 10% and censuses over 10 consecutive years. Power to detect declines in resident single occupancy within 5 years is below 0.8 unless all of the sites in the population are visited and declines are at least 15% annually (Figure A.5). However, the power to detect trend in resident single status is at or above 0.8 for annual samples of as few as 20 locations per year when the annual decline is 10% or greater over 10 years (Figure A.6). Power for trend detection within 5 years is consistently below 0.8 for the single unknown, unknown, and unoccupied categories, but power to detect trends within 10 years are near 0.8 for the single unknown and unoccupied categories when declines are at least 10% annually.

Overall, the power to detect trend in pair occupancy is excellent at the $\alpha = 0.2$ level. However, higher levels of effort or change are required for trend detection in other status categories because of their relative rarity. Maximum likelihood estimates of binomial probabilities that are close to 0 are generally unstable (Olkin et al., 1981). This may explain the decrease in power for an increasing number of sites in the power plot of unoccupied status (Figure 4.16).

Based on the results of the initial power analysis, the spotted owl workgroup determined that monitoring the occupancy of spotted owl pairs is of greatest importance. The relative rarity of the other status categories causes trend estimation to be more difficult unless changes are extreme. Data collection will continue for the other status categories so that baseline information is available for monitoring any future changes, but trends will only be calculated for spotted owl pairs.

In addition to focusing inference on the occupancy of spotted owl pairs, the results of the initial occupancy power analysis indicated that power to detect trend was adequate for a 5-year monitoring period. The final sampling design for occupancy and fecundity sampling needed to meet some additional criteria, including visiting all occupancy and fecundity sites at least once within one revisit cycle, obtaining an adequate fecundity sample size given that about 70% of occupancy sites are eligible for fecundity surveys, and possible restrictions on annual funding. Two possible funding scenarios were proposed: annual funding and funding for two consecutive year of high survey intensity followed by two years with low survey intensity. Based on these two funding scenarios and two proposed sample sizes from the fecundity analysis, four revisit designs were examined (Figures 4.5 to 4.8).

The four proposed revisit designs provide options for sampling designs given different levels and cycles of funding and for annual samples of 35 and 43 locations so that 25 and 30 fecundity sites may be visited in fully-funded years. The revisit design notation $(1\text{-}3)^{1/2}$ indicates that only half of the [1-3] panels are visited, so there are two [1-3] panels visited and no sites from this revisit design are surveyed in the other two years.

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Panel** | **Revisit design** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | [1-0] | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| 2 | [1-3] | 20 | | | | 20 | | | |
| 3 | [1-3] | | 20 | | | | 20 | | |
| ANNUAL TOTAL | | 35 | 35 | 15 | 15 | 35 | 35 | 15 | 15 |

*Figure 4.5: [(1-0)$^{10}$, (1-3)$^{1/2}$] revisit design for an annual sample of 35 sites*

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Panel** | **Revisit design** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | [1-0] | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 2 | [1-3] | 17 | | | | 17 | | | |
| 3 | [1-3] | | 17 | | | | 17 | | |
| ANNUAL TOTAL | | 43 | 43 | 26 | 26 | 43 | 43 | 26 | 26 |

*Figure 4.6: [(1-0)$^{26}$, (1-3)$^{1/2}$] revisit design for an annual sample of 43 sites*

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Panel** | **Revisit design** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | [1-0] | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| 2 | [1-3] | 8 | | | | 8 | | | |
| 3 | [1-3] | | 8 | | | | 8 | | |
| 4 | [1-3] | | | 8 | | | | 8 | |
| 5 | [1-3] | | | | 8 | | | | 8 |
| ANNUAL TOTAL | | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |

*Figure 4.7: [(1-0)$^{28}$, (1-3)] revisit design for an annual sample of 36 sites*

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Panel** | **Revisit design** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | [1-0] | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| 2 | [1-3] | 5 | | | | 5 | | | |
| 3 | [1-3] | | 5 | | | | 5 | | |
| 4 | [1-3] | | | 5 | | | | 5 | |
| 5 | [1-3] | | | | 5 | | | | 5 |
| ANNUAL TOTAL | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |

*Figure 4.8: [(1-0)$^{40}$, (1-3)] revisit design for an annual sample of 45 sites*

If location effects could be incorporated into the model, we would expect power to be lowest for the revisit design represented in Figure 1 and the highest for Figure 4 based on the increasing size of the annual revisit panel. The [1-0] annual panel sites will be selected from the list of sites that fall in both the occupancy and fecundity sampling frames. Then the remaining sites could be ordered randomly and allotted to the other panels. If needed, the sites included in both the occupancy and fecundity frames could be balanced among years in the remaining panels, thus also balancing the sites that historically have not contained successful nests.

The power for each revisit design is provided in Table 4.7. The power to detect trend is very high because the estimated occupancy rate is near 1, making declines easy to detect. Power was estimated to be near or equal to one for all revisit scenarios and both levels of change given a Type II error of 0.20, so power was also examined at the $\alpha = 0.10$ level. At this level, power is at or above 0.98 for all revisit designs. Because site-level effects are not incorporated in this occupancy analysis, power is conservative for trend detection. Furthermore, power calculated from this model is a function of the total sample size rather than of panel sample sizes.

Table 4.7: Power to detect trends in spotted owl pair occupancy within five consecutive survey years for four revisit designs

| **Revisit design** | **Power to detect a 4% annual decrease in occupancy** | | **Power to detect a 10% annual decrease in occupancy** | |
|---|---|---|---|---|
| | $\alpha = 0.10$ | $\alpha = 0.20$ | $\alpha = 0.10$ | $\alpha = 0.20$ |
| $[(1\text{-}0)^{15}, (1\text{-}3)^{1/2}]$ | 0.992 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{26}, (1\text{-}3)^{1/2}]$ | 0.992 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{28}, (1\text{-}3)]$ | 0.992 | 1.000 | 1.000 | 1.000 |
| $[(1\text{-}0)^{40}, (1\text{-}3)]$ | 0.996 | 1.000 | 1.000 | 1.000 |

### *4.3 Fecundity analysis*

Fecundity of spotted owls is measured by the number of fledglings per territorial female. Nesting spotted owls can produce 0 to 3 fledglings, though a maximum of two fledglings was observed from the pilot data. The 1998-2008 pilot data indicate that zero inflation may be an issue (Figure 4.5). Zero inflation may result from a high number of non-nesting pairs or nest failures related to predation or environmental factors.

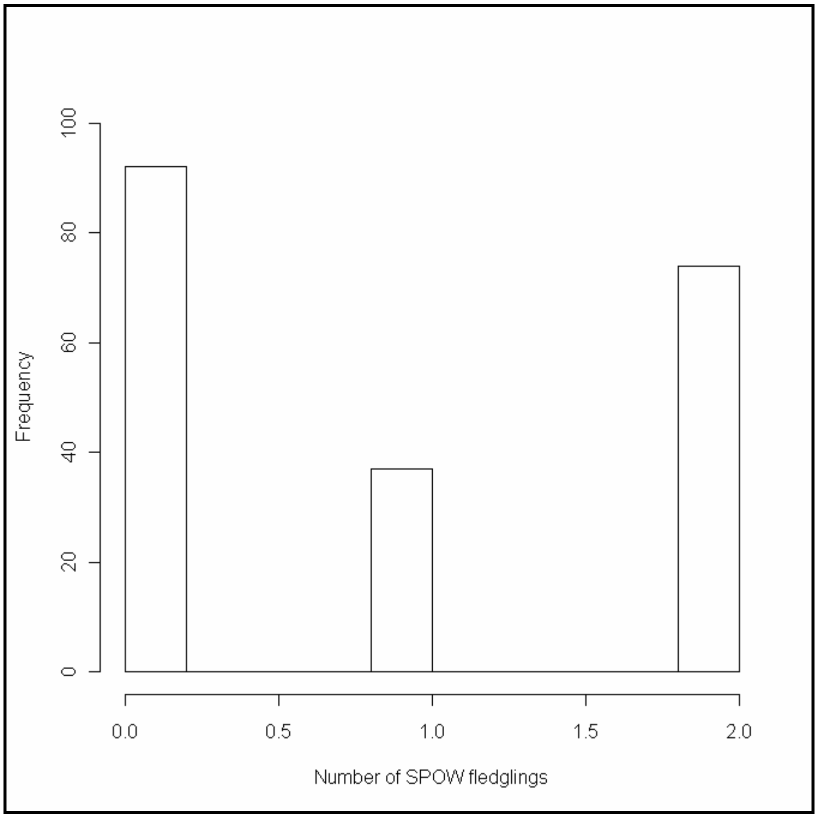

*Figure 4.5: Histogram of detected spotted owl fledglings across sites and years from the pilot data*

Fecundity is measured as the binomial probability for fledglings. These estimates are provided in Table 4.8 by year. While the estimates indicate an increasing trend (Figure 4.6), the increase is not significant (LRT test statistic: 0.0043, p-value: 0.9479). The probability of not detecting an extra zero is estimated as 0.6395 (SE 0.0466).

Table 4.8: Estimated binomial probabilities for fledgling

| **Year** | **Estimated binomial probability for fledglings (SE)** |
|---|---|
| 1999 | 0.4715 (0.0686) |
| 2000 | 0.4724 (0.0574) |
| 2001 | 0.4732 (0.0473) |
| 2002 | 0.4741 (0.0393) |
| 2003 | 0.4750 (0.0349) |
| 2004 | 0.4758 (0.0353) |
| 2005 | 0.4767 (0.0405) |
| 2006 | 0.4776 (0.0490) |
| 2007 | 0.4784 (0.0593) |
| 2008 | 0.4793 (0.0707) |

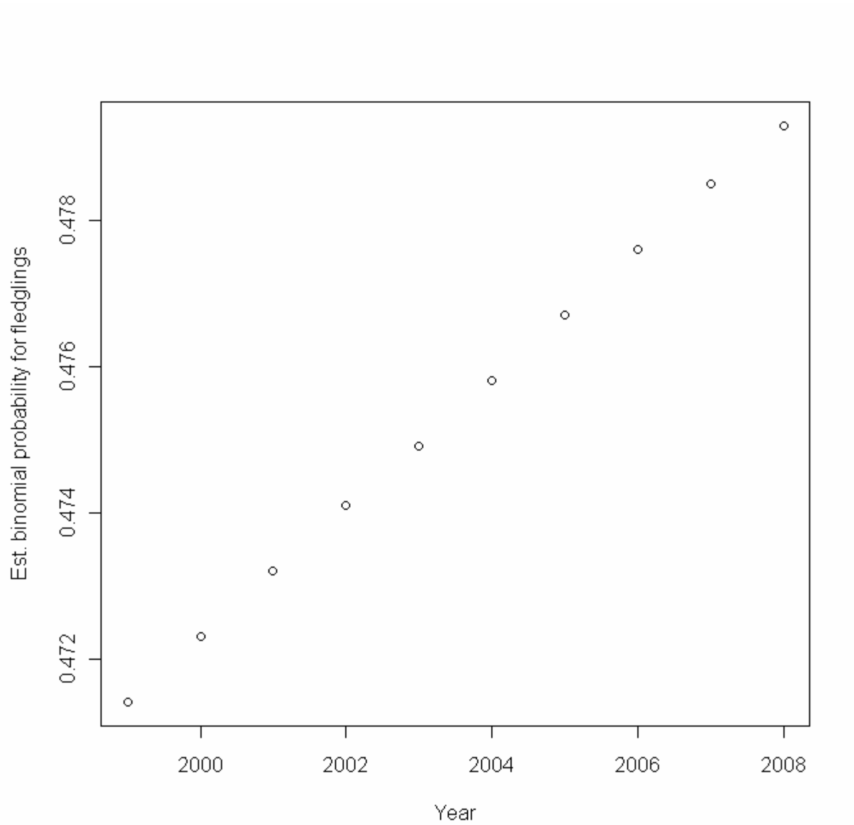


*Figure 4.6: Estimated binomial probabilities for spotted owl fledglings by year*

The power to detect trends in fledgling rates is calculated as described in section 2.2. The intercept-only model for zero-inflation is constant across all locations and years. The fledgling rate model is allowed to change linearly across years for trend testing. The power to detect decreasing trends in spotted owl fecundity is based on the likelihood ratio test for monitoring periods of 5 years (Figure 4.7) and 10 years (Figure 4.8). Twenty to 25 locations with resident females must be surveyed annually to detect decreasing trends of at least 10% within 5 years. Power to detect a 4% decline within 5 years never exceeds 0.5. For a 10-year monitoring period, power to detect decreasing trends of at least 10% is at least 0.8 for samples as low as 10 occupied locations per year. Around 30 nests must be visited annually to detect a 4% decline with power of 0.8 within 10 years. Out of 25 sites selected for fecundity monitoring, the 2007 and 2008 surveys resulted in 12 sites with territorial females for fecundity analysis. At this level of effort, longer monitoring time frames are required to achieve adequate power for trend detection.

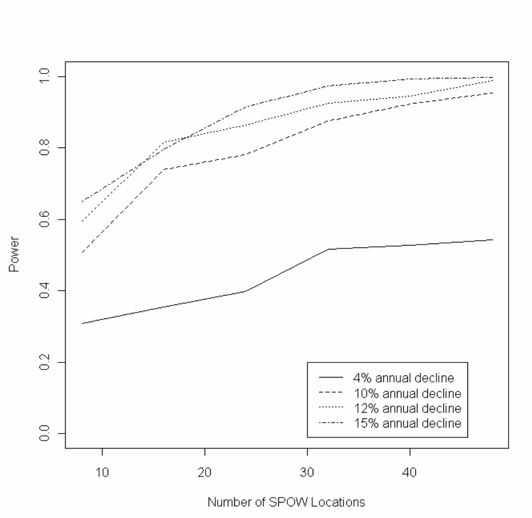


*Figure 4.7: Power to detect trend in the binomial probability of spotted owl hatchling success in 5 consecutive survey years for four rates of change*

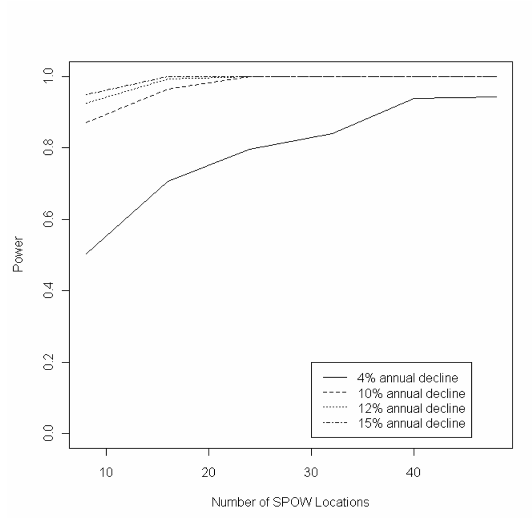


*Figure 4.8: Power to detect trend in the binomial probability of spotted owl hatchling success in 10 consecutive survey years for four rates of change*

### *4.4 Conclusions*

The power to detect decreasing trends in spotted owl occupancy is nearly 1 for the pair occupancy status. Power to detect declines in sites with resident singles, sites with single spotted owls with unknown status, and in unoccupied sites exceeds 0.8 when annual declines are at least 10% for monitoring of at least 10 years. Power to detect trends in the pair unknown and unknown categories is uniformly low based on the rarity of these status categories.

The power to detect trends in spotted owl fecundity within 5 years is at least 0.8 when the annual decline is at least 10% and at least 25 to 30 sites with known reproductive outcomes are visited annually. Given that roughly 70% of the sites visited qualify for fecundity monitoring, an initial sample of 35 to 43 sites is needed to obtain the desired sample size. For a 10-year monitoring window, power is around 0.9 even for annual fecundity samples as small as 10 territories when annual declines are at least 10%. When the annual decline is 4% over 10 years, at least 30 territories must be surveyed annually to achieve power of 0.8 or more.

## 5. CONCLUSIONS

Overall, power for trend detection is high for prairie falcon and spotted owl monitoring. For prairie falcon monitoring, 27 to 30 (18 core and 9 to 12 non-core) territories should be visited annually to achieve power of 0.8 to detect a net decline in pair occupancy of 50% in 10 years. Power to detect a similar trend in fecundity measures may be obtained by monitoring fecundity in at least 10 pair-occupied sites.

A preliminary power analysis indicated that power to detect trends in spotted owl pairs exceeds 0.9 at the $\alpha = 0.2$ level. Because other status categories were relatively rare and power for trend detection was low, these categories will be tracked over time but not monitored for trend. Four possible revisit designs at various levels of effort in a five-year period are proposed, each provided power of about 1.00 for trend detection in pair occupancy at the $\alpha = 0.2$ level.

The power analysis was ultimately based on a [1-n] design because a fixed or random site effect could not be incorporated into the zero-inflated binomial models. Therefore, the benefits of sampling the same sites through time could not be used to reduce the estimate of the trend variance for higher power. However, this restriction means that the power analysis is conservative. MacKenzie et al. (2006) suggest that a Bayesian analysis might resolve this problem encountered in maximum likelihood estimation. If maximum estimation is to be used to trend estimation and testing, then MacKenzie et al. (2006) recommend using a [1-0] revisit design so that additional sites do not rotate into the sample from year to year and increase site-to-site variation. This additional variation cannot be explained by the model, and the additional unexplained error reduces power to detect trend. Site-level covariates related to occupancy could be incorporated into the occupancy model to account for some site-to-site differences in occupancy.

From panel design theory, it is known that revisiting the same sites each year provides the highest power for trend detection and visiting an independent random sample each year gives the lowest power to detect trend (Urquhart and Kincaid, 1999). Skipping survey years increases the amount of time required to detect trends, but adding a panel of sites visited annually can increase the power to nearly that of the always-revisit design. Without specific information to compare revisit designs, SFAN personnel may need to rely on management needs to determine what revisit design is best. If all prairie falcon territories or spotted owl locations need to be visited in a cycle, then incorporating a revisit design that visits a majority of the same sites annually will help reduce site-to-site variation. Visiting the remaining sites with a serially-alternating revisit schedule will ensure that all sites are evaluated regularly.

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**APPENDIX A: Power to detect trends in spotted owl occupancy status categories by revisit design**

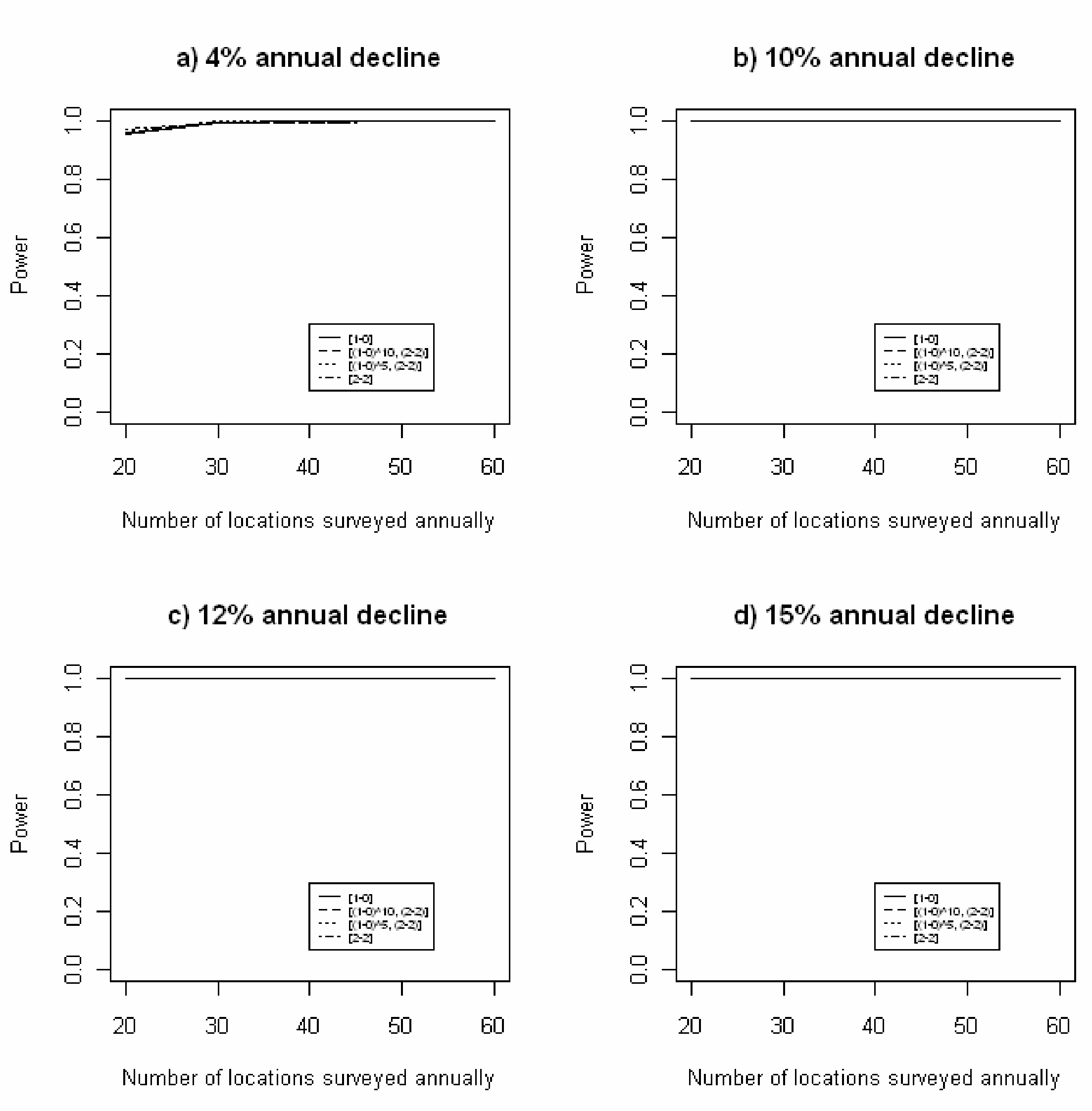


*Figure A.1: Power to detect population declines in PR occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

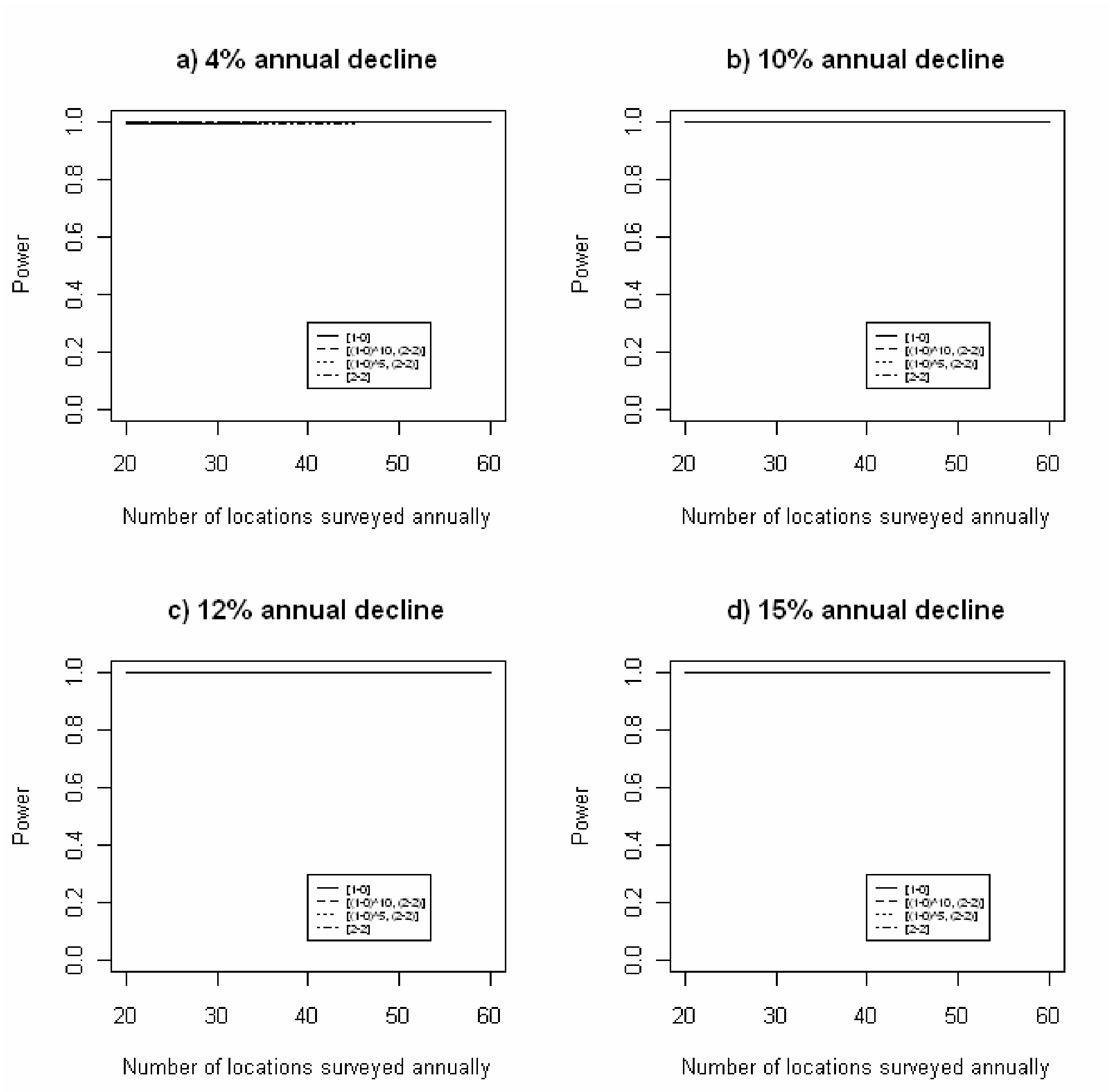


*Figure A.2: Power to detect population declines in PR occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

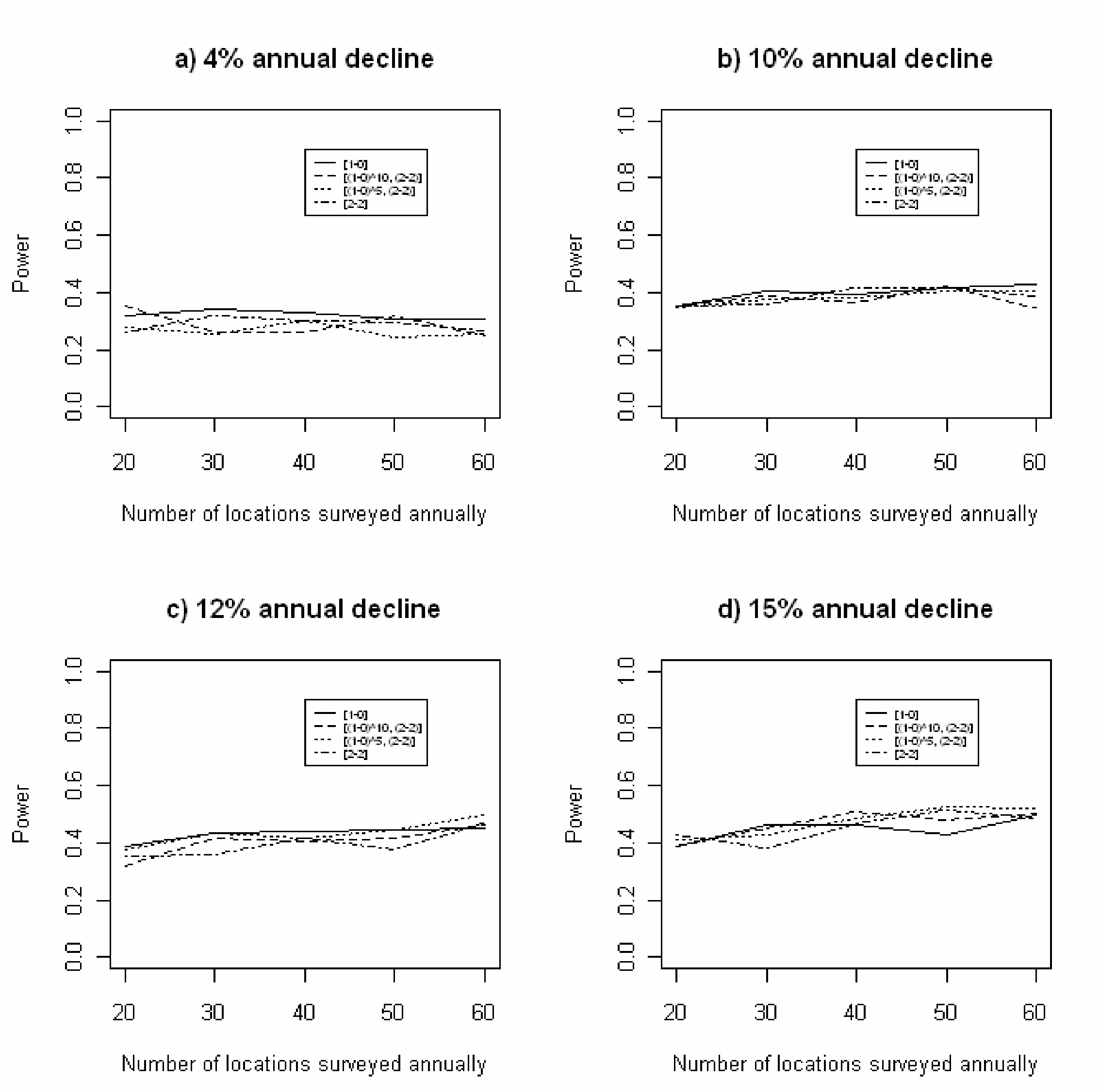


*Figure A.3: Power to detect population declines in PU occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

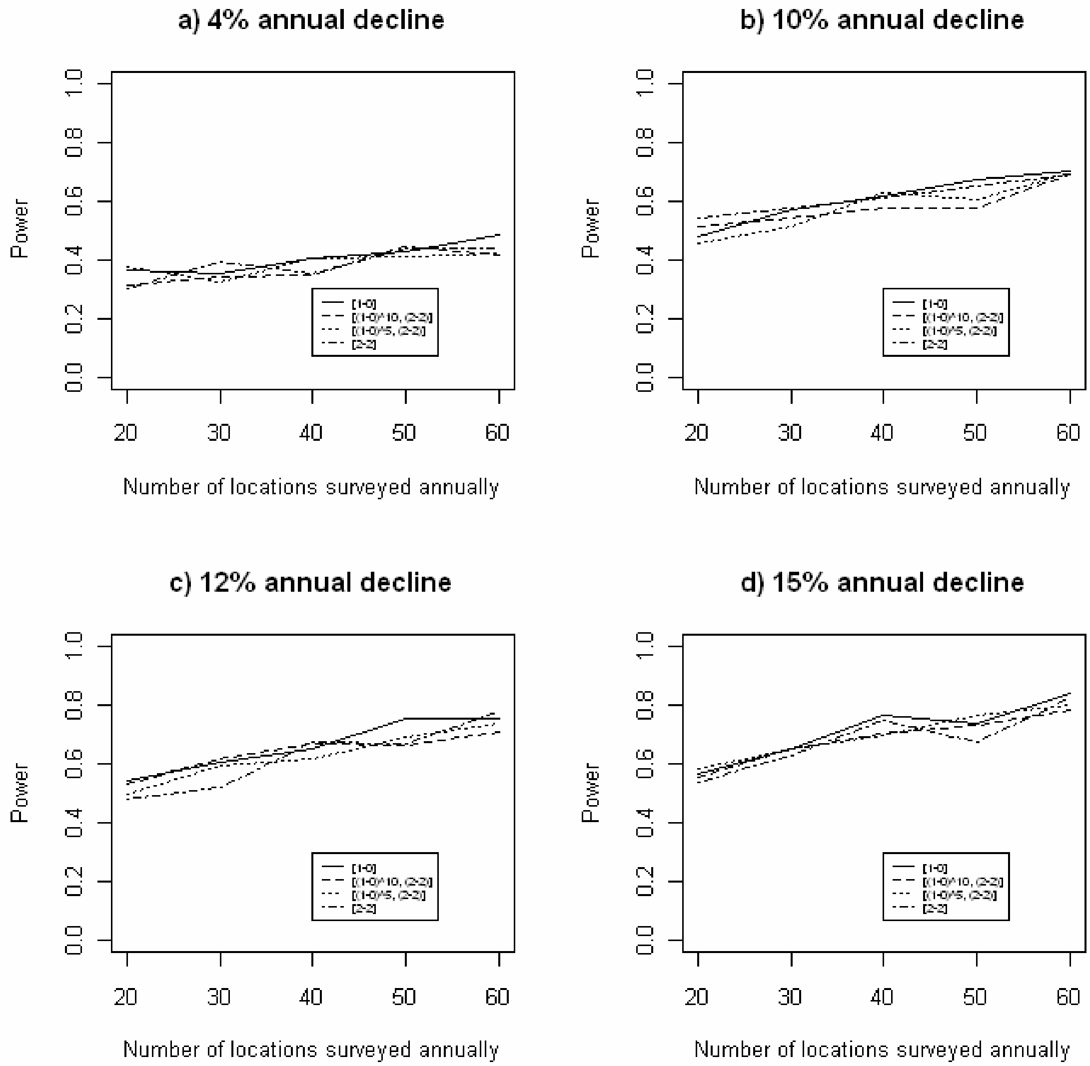


*Figure A.4: Power to detect population declines in PU occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

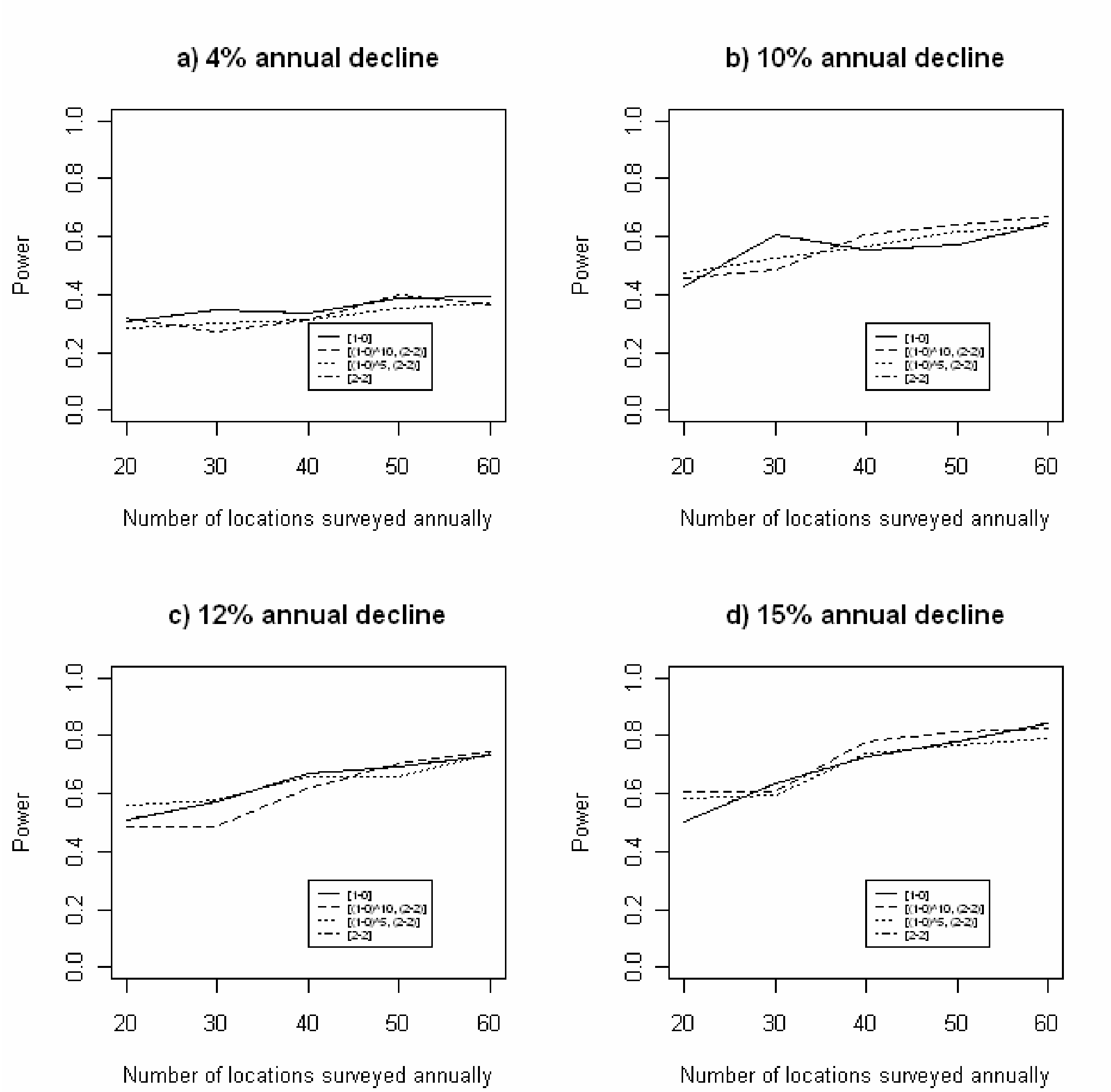


*Figure A.5: Power to detect population declines in RS occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

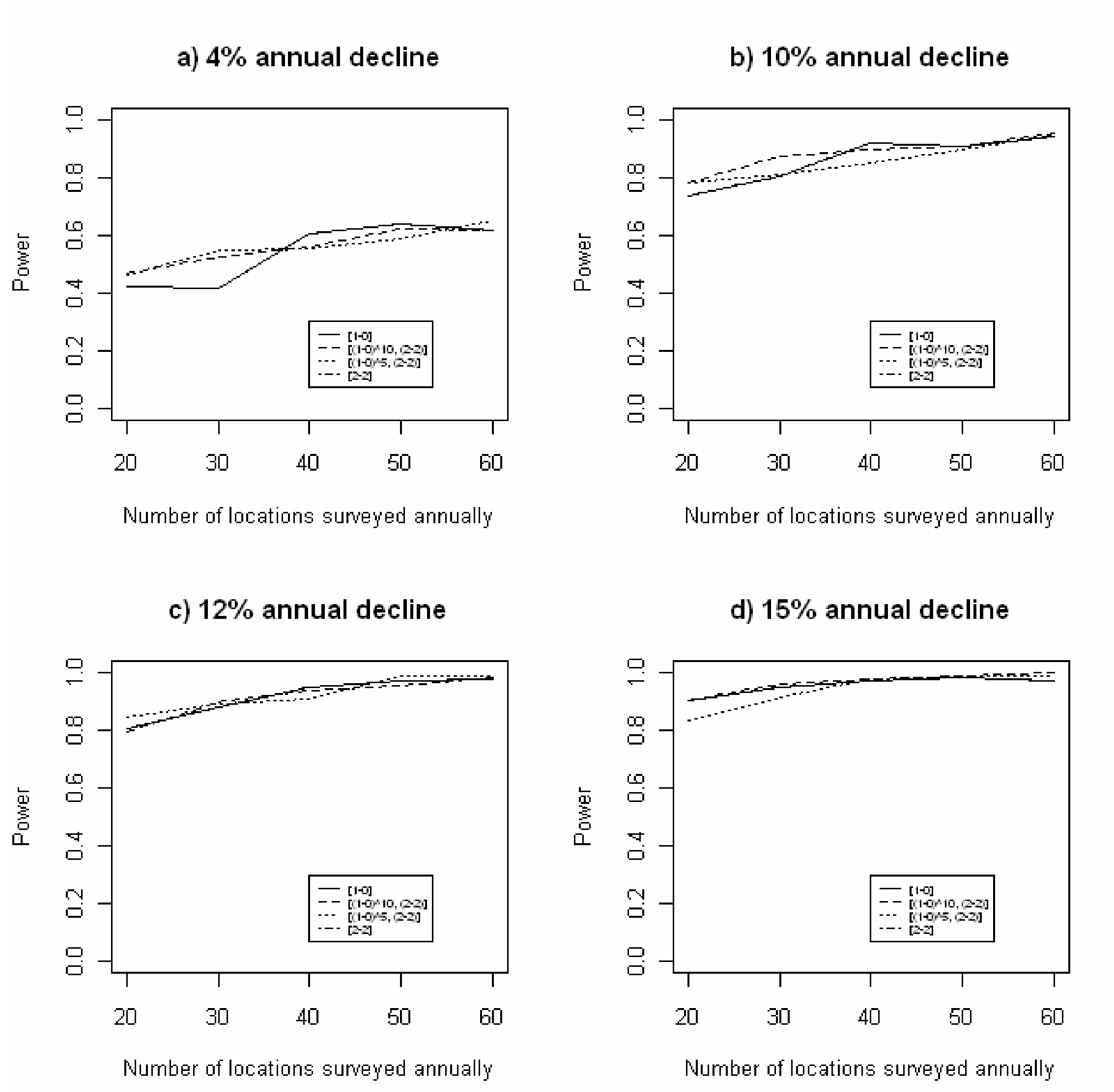


*Figure A.6: Power to detect population declines in RS occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

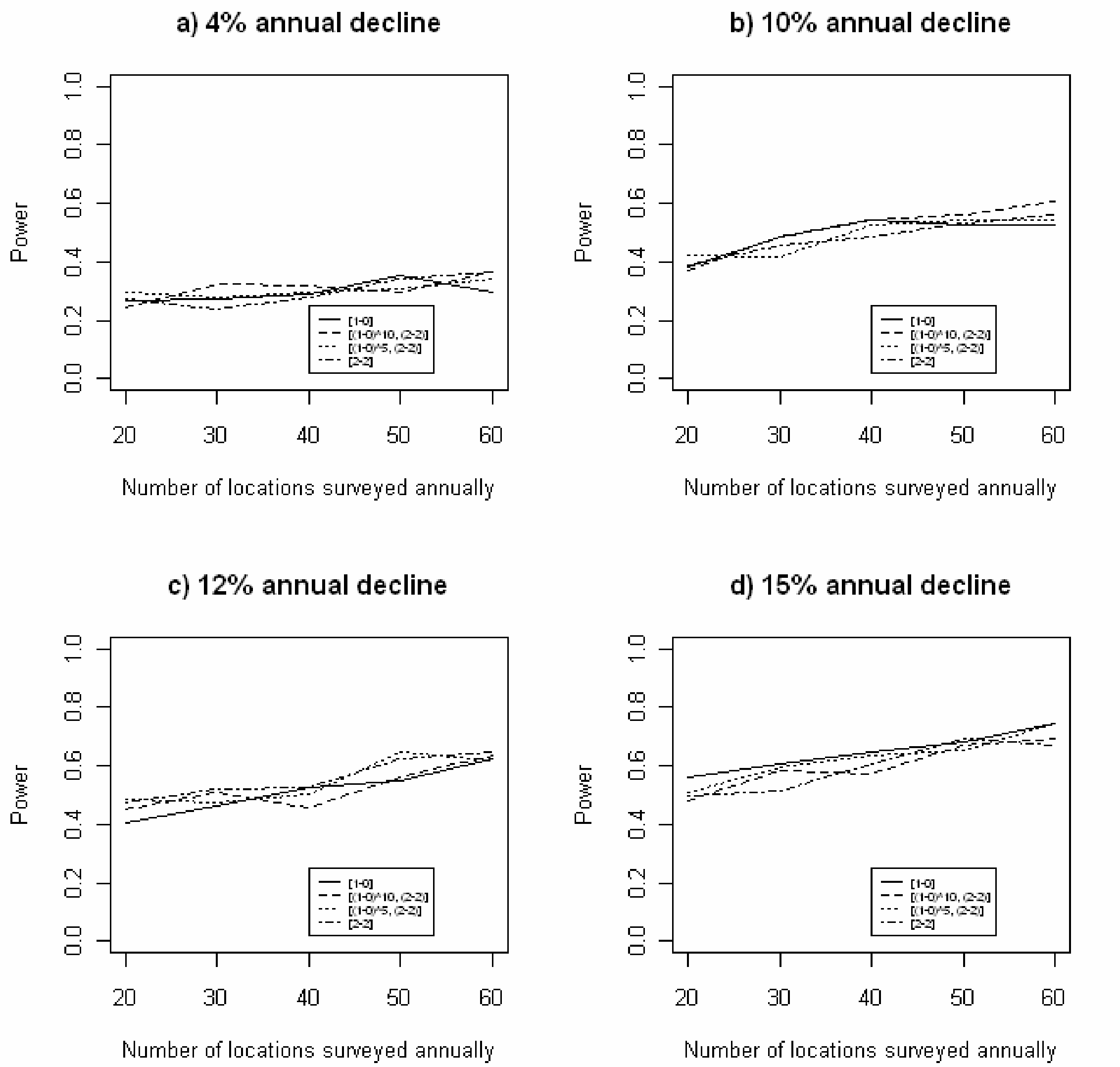


*Figure A.7: Power to detect population declines in SU occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

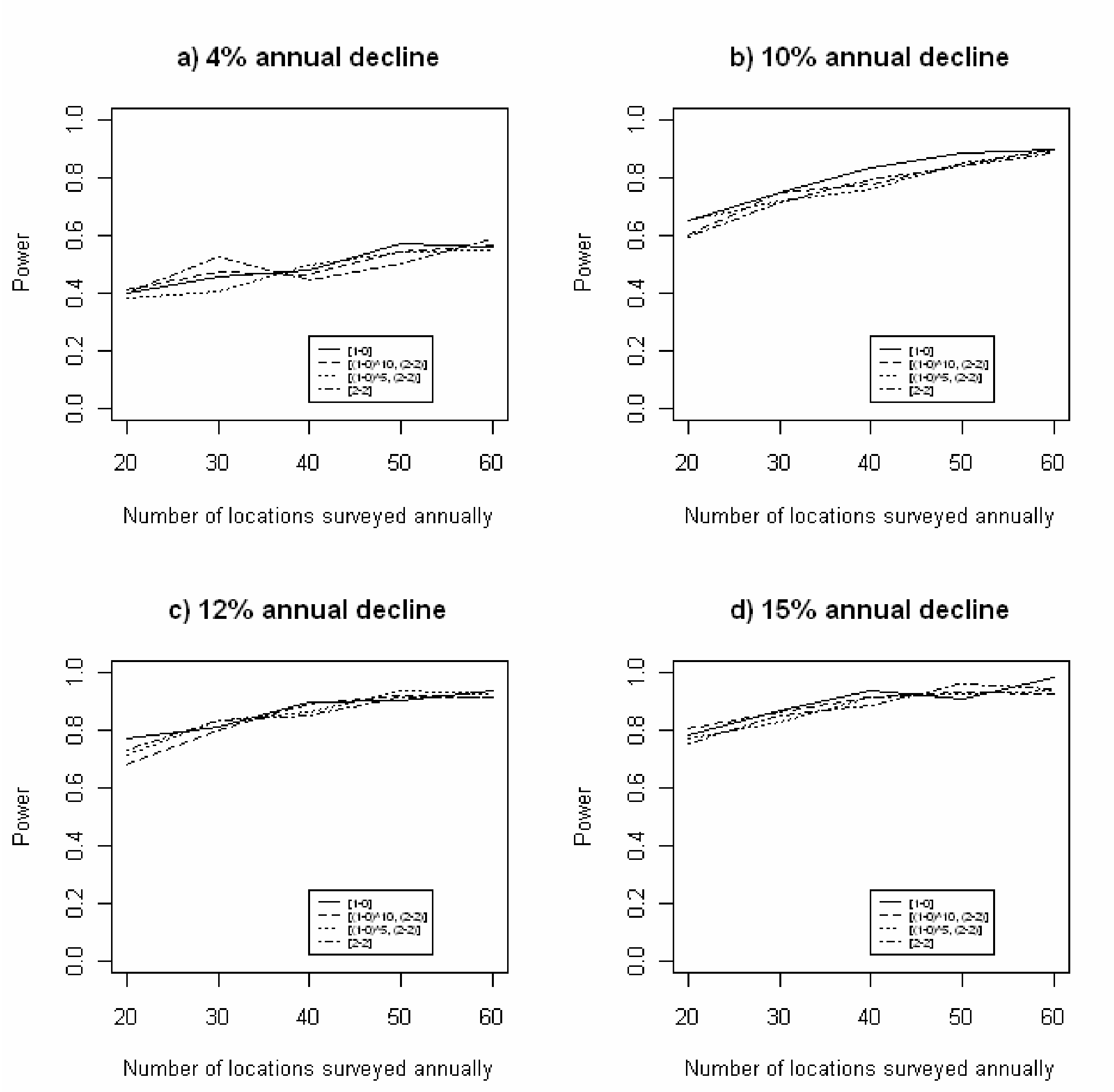


*Figure A.8: Power to detect population declines in SU occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

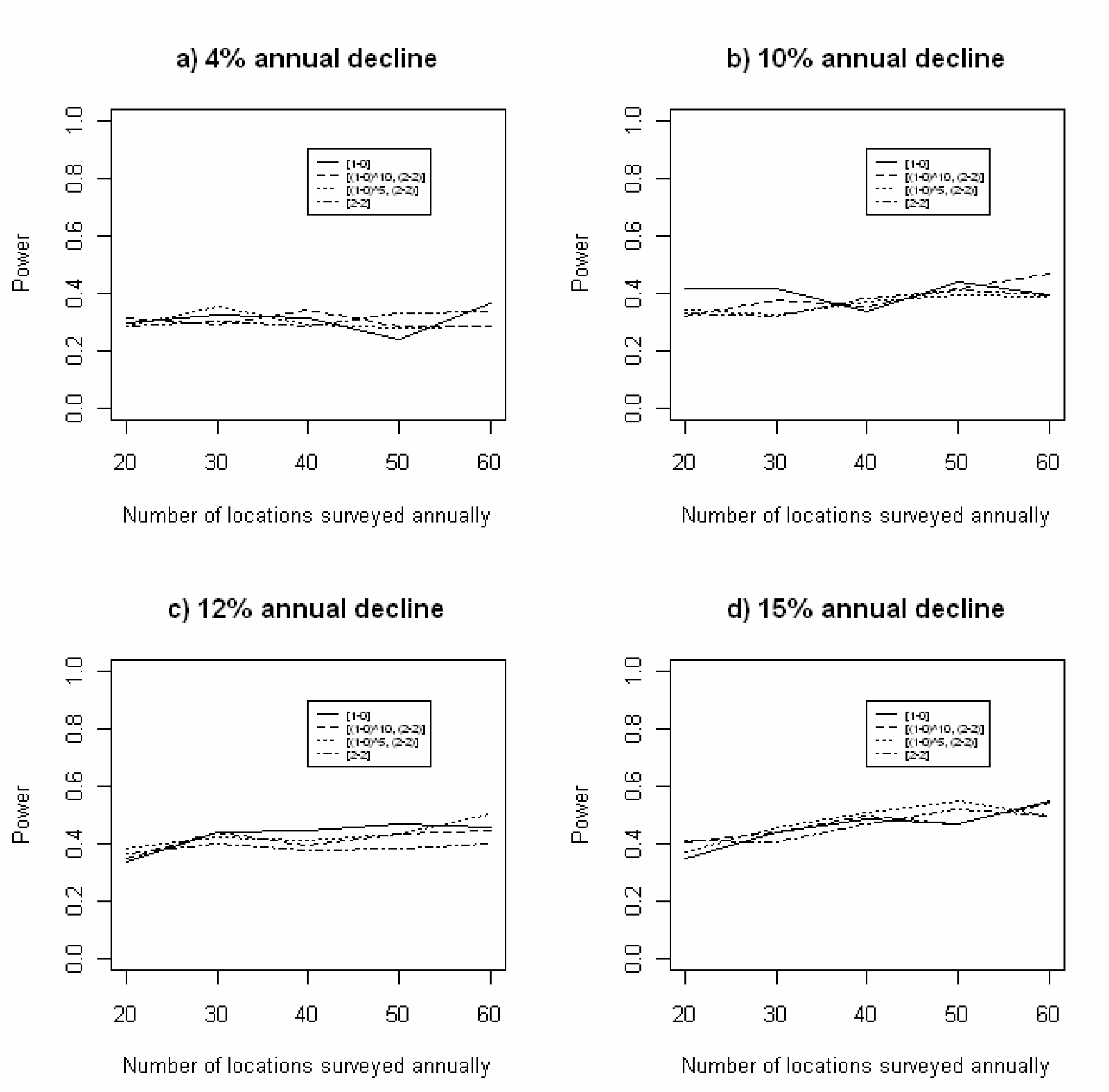


*Figure A.9: Power to detect population declines in UK occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

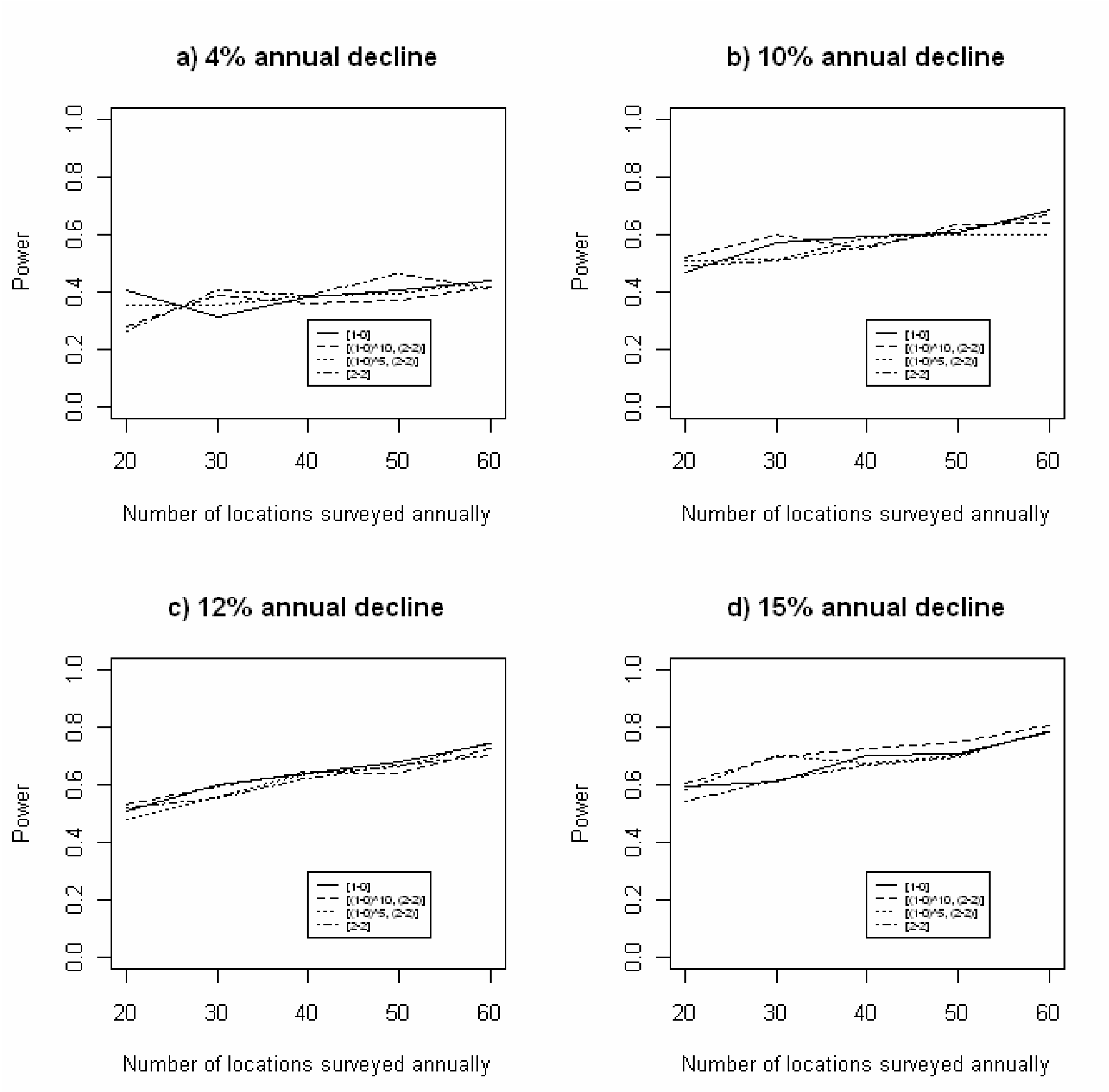


*Figure A.10: Power to detect population declines in UK occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

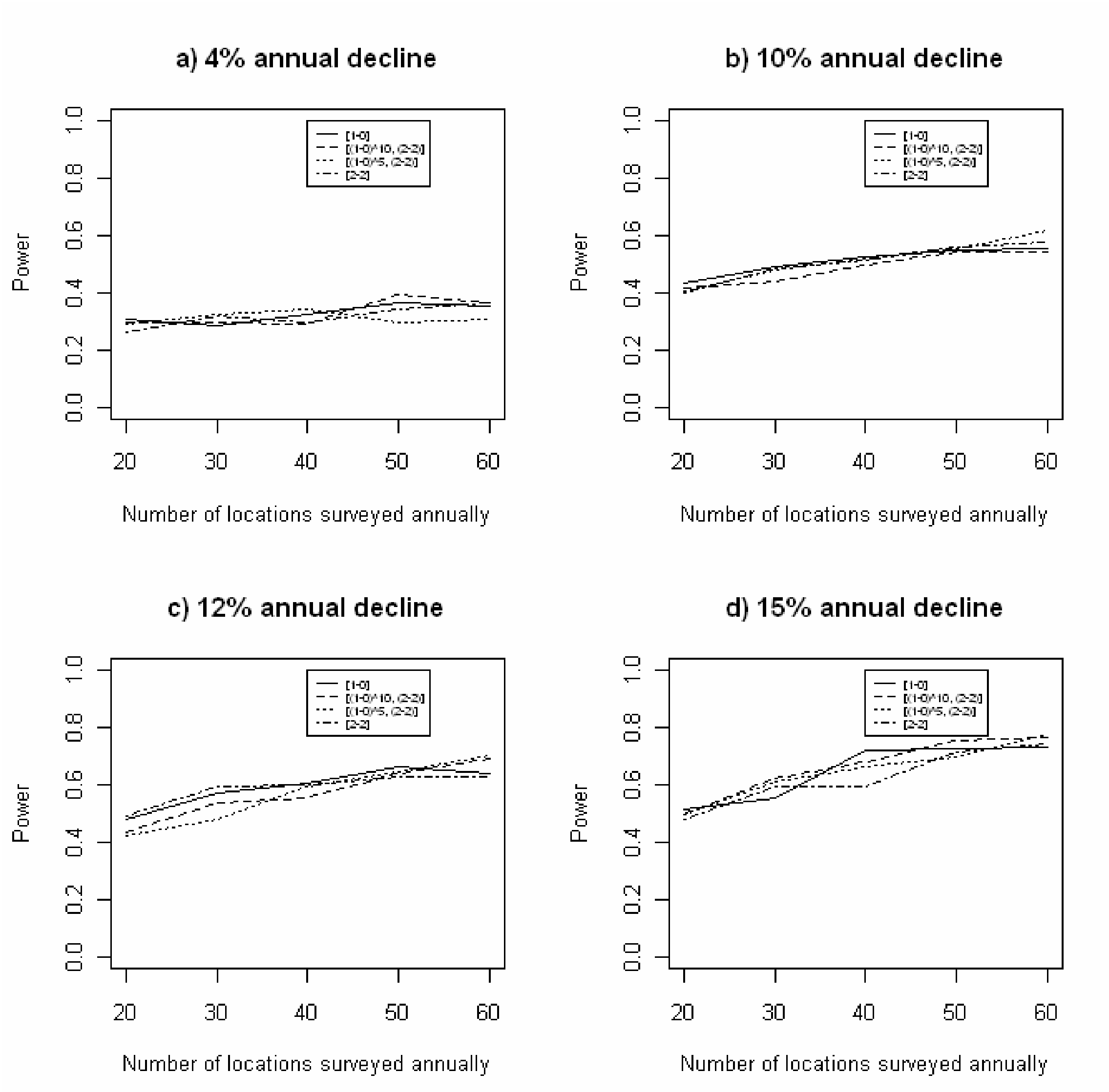


*Figure A.11: Power to detect population declines in UO occupancy in tests of trend over 5 consecutive survey years for the α=0.20 significance level*

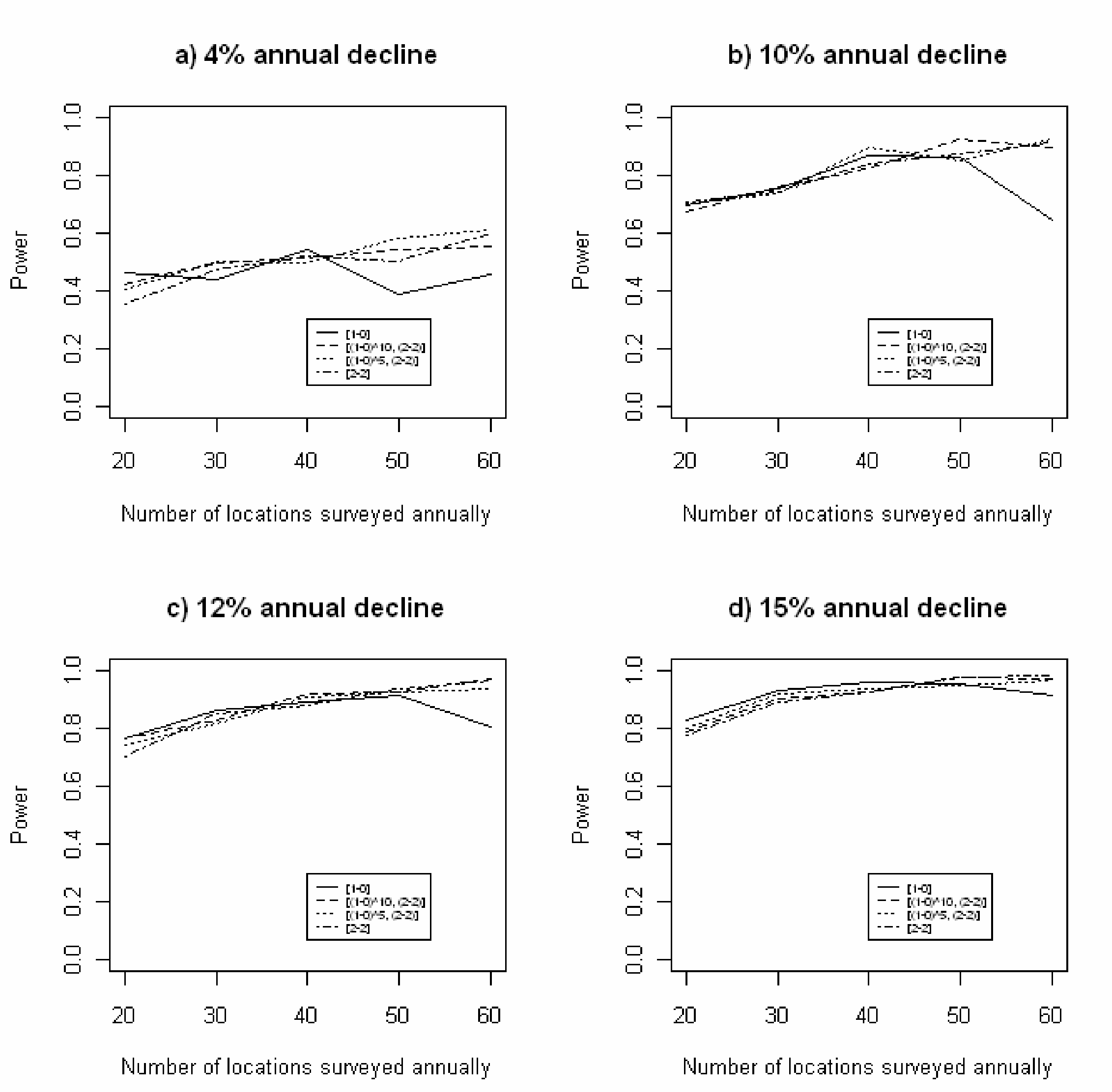


*Figure A.12: Power to detect population declines in UO occupancy in tests of trend over 10 consecutive survey years for the α=0.20 significance level*

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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